

SECTION 7

LIGHTING AND POWER DISTRIBUTION SYSTEMS

Table of Contents

	<u>Page No</u>
7.1 GENERAL	1
7.1.1 INTRODUCTION	1
7.1.2 CODES AND STANDARDS	2
7.1.3 ALTERNATE EQUIPMENT AND MODIFICATION OF DESIGN CRITERIA	3
7.1.4 REFERENCE PUBLICATIONS	4
7.2 LIGHTING SYSTEM DESIGN	4
7.2.1 LIGHTING WARRANT ANALYSIS	6
7.2.1.1 Roadway Lighting	7
7.2.1.2 Underbridge Lighting	12
7.2.1.3 Sign Lighting	12
7.2.1.4 Roadway Tunnel Lighting	13
7.2.1.5 Parking Lot Lighting	14
7.2.1.6 Storage Facilities and Maintenance Yards Lighting	14
7.2.1.7 Aesthetic Lighting	14
7.2.1.8 Navigation and Aviation Obstruction Lighting	14
7.2.2 REQUIRED AREA OF ILLUMINATION	14
7.2.2.1 Continuous Lighting on Roadways	15
7.2.2.2 Deceleration Lanes	15
7.2.2.3 Acceleration Lanes	17
7.2.2.4 Merge, Weaving, and Diverge Areas	18
7.2.2.5 Ramp Termini	20
7.2.2.6 Toll Plaza Merge Areas	22
7.2.2.7 Parking / Maintenance / Storage Facilities	24
7.2.2.8 Roadway Tunnels	24
7.2.3 LIGHTING DESIGN CRITERIA	24
7.2.4 SELECTION OF ROADWAY LIGHTING SYSTEM	27
7.2.4.1 Approved Roadway Lighting Systems	27
7.2.4.2 Selection of System	29
7.2.5 DESIGN CONSIDERATIONS	31
7.2.6 LIGHTING CALCULATION METHOD	32
7.2.6.1 Software and Setup	32
7.2.6.2 Calculation Zones	33
7.2.6.3 Luminaires and Photometrics	34
7.2.6.4 Additional Considerations	36

7.2.6.5	Verification of Lighting Design.....	36
7.3	LIGHTING EQUIPMENT AND MATERIALS.....	37
7.3.1	ROADWAY LIGHTING STANDARDS.....	37
7.3.2	ROADWAY LIGHTING LUMINAIRES.....	42
7.3.3	HIGHMAST AND FLOODLIGHTING SYSTEMS	44
7.3.4	EMERGENCY LIGHTING AND GENERATOR BACKUP	45
7.3.5	UNDERBRIDGE LIGHTING	46
7.3.6	TOLL PLAZA LIGHTING	47
7.3.7	ROADWAY TUNNEL LIGHTING	47
7.3.8	MAINTENANCE AREA / STORAGE AREA LIGHTING	47
7.3.9	PARKING LOT LIGHTING.....	47
7.3.10	TEMPORARY ROADWAY LIGHTING	47
7.3.11	SIGN LIGHTING.....	49
7.3.12	NAVIGATION AND AVIATION OBSTRUCTION LIGHTING.....	49
7.3.13	LIGHTING STANDARD BASES AND JUNCTION BOX FOUNDATIONS	49
7.4	POWER DISTRIBUTION AND RACEWAY SYSTEM DESIGN	50
7.4.1	GENERAL.....	50
7.4.2	ELECTRIC SERVICE.....	50
7.4.2.1	General.....	50
7.4.2.2	Building Electrical Services.....	51
7.4.2.3	Services Not Located at Buildings.....	51
7.4.2.4	Utilized Voltage.....	51
7.4.3	CIRCUITRY AND VOLTAGE DROP	53
7.4.4	RACEWAY SYSTEM DESIGN.....	60
7.4.4.1	Underground Junction Boxes, Handholes, and Manholes.....	60
7.4.4.2	Conduits and Raceways.....	61
7.4.5	TEMPORARY POWER DISTRIBUTION SYSTEMS	67
7.5	POWER DISTRIBUTION AND RACEWAY SYSTEMS EQUIPMENT AND MATERIAL	68
7.5.1	CONDUITS, CABINETS, WIREWAYS AND FITTINGS.....	68
7.5.2	CABLES AND WIRES	70
7.5.3	STANDALONE LOAD CENTERS	71
7.6	DESIGN SUBMISSION REQUIREMENTS	71
7.6.1	PHASE “A” CONCEPTUAL DESIGN SUBMISSION.....	71
7.6.2	PHASE “B” SUBMISSION	73
7.6.3	PRE-PHASE “C” SUBMISSION	74

7.6.4	PHASE "C" SUBMISSION	76
7.6.5	PHASE "D" SUBMISSION	76
7.7	PREPARATION OF CONTRACT DOCUMENTS.....	76
7.7.1	PLANS.....	76
7.7.1.1	Required Plans.....	76
7.7.1.2	Additional Plan Requirements.....	81
7.7.1.3	Standard Legends and Symbols	81
7.7.2	SPECIFICATIONS.....	82

List of Exhibits

	<u>Page No</u>
Exhibit 7 - 1 Warranting Conditions for Complete Interchange Lighting.....	8
Exhibit 7 - 2 Warranting Conditions for Partial Interchange Lighting.....	9
Exhibit 7 - 3 Required Design Area for Typical Ramp	15
Exhibit 7 - 4 Required Design Area for Deceleration Lane.....	16
Exhibit 7 - 5 Required Design Area for Multiple Deceleration Lanes.....	16
Exhibit 7 - 6 Table of Distances for Deceleration Lane Lighting	17
Exhibit 7 - 7 Required Design Area for Acceleration Lane	17
Exhibit 7 - 8 Table of Distances for Acceleration Lane Lighting.....	18
Exhibit 7 - 9 Required Design Area for Merge/Weaving Area	19
Exhibit 7 - 10 Required Design Area for Diverge Area.....	20
Exhibit 7 - 11 Required Design Area for Typical Ramp Terminus	21
Exhibit 7 - 12 Required Design Area for Ramp Terminus at Signalized Intersection	21
Exhibit 7 - 13 Small Toll Plaza Design Area.....	22
Exhibit 7 - 14 Large Toll Plaza Design Area	23
Exhibit 7 - 15 Typical Design Area for Parking Facility.....	24
Exhibit 7 - 16 Table of Illumination and Uniformity Requirements.....	25
Exhibit 7 - 17 Table of Light Loss Factors.....	27
Exhibit 7 - 18 Lamp Types, Wattages, Lumens, and Rated Life	36
Exhibit 7 - 19 Lighting Standard Designation Method	38
Exhibit 7 - 20 Typical Roadway Lighting Standard Arrangements	40
Exhibit 7 - 21 Type P Luminaire Installation Guidelines	44
Exhibit 7 - 22 Sample Voltage Drop Calculation Forms 1 and 2	56
Exhibit 7 - 23 Table of Ballast Input Wattage / Current.....	60
Exhibit 7 - 24 Installation of Communications Conduit on Authority Bridges.....	65

Exhibit 7 - 25 Communications Conduit Installation Details	66
Exhibit 7 - 26 Schedule of Lighting Standards and Luminaires	80

SECTION 7

LIGHTING AND POWER DISTRIBUTION SYSTEMS

7.1 GENERAL

7.1.1 Introduction

Construction projects on the New Jersey Turnpike and Garden State Parkway will likely impact or require the construction of Lighting and Power Distribution Systems.

These systems may include, but are not limited to, lighting installations for new roadways, bridges, toll plazas, signs, parking areas, maintenance facilities, and storage yards, and/or modifications to various existing systems throughout the Turnpike and Parkway. They also include installation of power to non-lighting equipment, such as traffic counting and weather stations, loops, variable and changeable message signs, lane use signs, warning lights, cameras, and other Intelligent Traffic Systems (ITS) devices that require power.

This Section is not meant to describe the installation of specific ITS Systems equipment, or installation of communications systems such as fiber, telephone, and radio transmission. See Section 8 (ITS and Communications Systems) of this Manual a discussion of installation for these systems. See also Section 7 (Utility Installations, Relocations and Adjustments) of the Procedures Manual for a discussion of Utility Installations.

Installation of raceway systems to be utilized for Communications Systems shall be designed as described in this section, and as modified by Section 8 (ITS and Communications Systems) of this Manual.

For installation of Toll Plaza Systems, and power and lighting systems installed within Authority buildings, see Section 11 (Facility Buildings/Toll Plazas) of this Manual.

All traffic signal systems shall be designed and constructed in accordance with the requirements of the New Jersey Department of Transportation, as amended by local requirements of the signal owner or maintainer.

This Section is not intended to be a design handbook, but rather a guideline covering the Authority's current standards for system design and preparation of contract documents. It is essential that the basic criteria covered in this manual be followed as closely as possible by the electrical engineering staff of each Engineer in order to achieve uniform and consistent Lighting and Power Distribution Systems throughout Turnpike and Parkway facilities.

Satisfying all of these criteria will necessitate sound judgment and good engineering practice on the part of the Engineer. Where special designs deviate from these basic criteria, the Engineer shall secure written approval

from the Authority's Engineering Department. See Subsection 7.1.3 for more information on this subject.

Lists of items or descriptions included in this Section in order to illustrate various concepts shall not be interpreted as being all inclusive. Due to the varied nature of the Authority's Facilities, many exceptional cases may be encountered.

Where information shown on or contained within the Standard Drawings or Standard Specifications differs from the direction given in this Section, the Engineer shall submit a written letter to the Authority's Engineering Department asking for clarification before commencing design of the particular item in question. This procedure has been put in place to prevent confusion during the various project reviews, and to prevent different interpretations of the relevant design requirements after design has been completed.

The Engineer should feel free, at any time, to contact the Authority's Engineering Department to receive consultation on extraordinary issues or interpretations of this Section prior to design or submission.

Throughout this Section, reference is made to Standard Drawings that have not been published as of the writing of this Manual. For more information regarding these updated Standard Drawings, please contact the Authority's Engineering Department.

7.1.2 Codes and Standards

All Lighting and Power Distribution Systems shall be installed in compliance with the National Electric Code (hereafter referred to as the NEC). The version used shall be the same version adopted by the state of *New Jersey Department of Community Affairs Division of Codes and Standards* (hereafter referred to as the DCA) for use on all new construction projects statewide.

As mentioned above, this Section is not meant to offer information on how to design Lighting and Power Distribution Systems. Roadway and other lighting systems shall be designed utilizing the procedures found in AASHTO Publication GL-6 *Roadway Lighting Design Guide* and the other reference publications listed below, and Power Distribution Systems shall be designed in accordance with standard industry practice, codes, and sound engineering judgment. This Section lists design and plan preparation requirements that are specific to the needs of the Authority. In case of any discrepancies between any other design guide and this Section, the direction given in this Section shall govern. Submitted designs will be reviewed according to the requirements of this Section and the other recommended practices in the reference publications.

Where Authority-sponsored projects disrupt, modify, or install Lighting or Power Distribution systems for other stakeholders, other codes and

standards may apply. The Engineer shall determine at the start of the project any additional codes and/or standards, and design manuals which may apply, and shall submit a summary of the findings for the Phase "A" Submission prior to any actual system design. If the various stakeholders do not dictate an alternate method for design or construction, the procedures and criteria listed herein shall apply.

7.1.3 Alternate Equipment and Modification of Design Criteria

The Engineer shall be responsible for the design of the Lighting and Power Distribution Systems and preparation of the Plans and Specifications.

Standard electrical equipment is pre-approved by the Authority on an on-going basis, and the approved model and drawing numbers are noted for these items in the Electrical Standard Drawings (to be released at a later date). The Engineer shall use, to the greatest extent possible, these standard components when developing system designs.

When, in the opinion of the Engineer, criteria outlined in this Section cannot be achieved using standard equipment due to unique physical or geometric conditions or other limiting factors, the Engineer shall solicit the opinion of the Authority's Engineering Department. In such cases, the Engineer shall submit a comprehensive analysis of design parameters, including supporting calculations and related data, for approval.

The Authority's Engineering Department shall have final approval of all special inquiries made by Engineers in the course of seeking approval for substitute or alternative equipment proposed for use on Turnpike or Parkway projects, whether proposed by the Engineer or the Contractor.

When, in the opinion of the Engineer and according to sound engineering judgment, it is not possible to meet the lighting, power, or electrical design criteria outlined in this Section with any type of equipment due to unique limiting factors, and/or the Engineer believes that the procedures and criteria in this Section should be amended for a specific project, the Engineer shall request a modification of design criteria. Requests for modifications to criteria shall indicate the exact requirements to be waived and shall include a description of the underlying engineering analysis. All requests for modification shall be prepared on the Authority's "Design Element Modification Request" form and shall be prepared, submitted, and approved as described in Section 3 (Submission Requirements) of the Procedures Manual as part of the Phase "A" Submission. If any specific design criteria are not met by a submitted design and appropriate "Design Element Modification Request" forms have not been prepared and approved by the Authority's Engineering Department, the submission will be rejected without further or complete review, and resubmission will be required.

Approval of non-standard equipment or modifications to design criteria on one project or portion of a project shall not be interpreted as a mandate for

similar waiver of Authority standards in other project locations without separate requests submitted in accordance with the above procedures.

The implementation of all non-standard electrical equipment that is permitted by the Authority as part of system design shall be reviewed and approved by the Engineer prior to Contractor's order, fabrication or use of such equipment.

7.1.4 Reference Publications

The following publications have been referenced in developing this Section for Lighting and Power Distribution Systems, and shall serve as a reference to design information that is not specifically included in this manual.

An Informational Guide for Roadway Lighting. American Association of State Highway and Transportation Officials (AASHTO).

American National Standard Practice for Tunnel Lighting. Illuminating Engineering Society of North America (IESNA). Publication Number RP-22-96.

American National Standard Practice for Roadway Lighting. Illuminating Engineering Society of North America (IESNA). Publication Number RP-8-00.

Roadway Lighting Design Guide. American Association of State Highway and Transportation Officials (AASHTO). Publication Number GL-6.

Roadway Lighting Handbook. Federal Highway Administration (FHWA).

Standard Specifications. New Jersey Turnpike Authority, latest version.

Standard Electrical Drawings. New Jersey Turnpike Authority, latest version.

National Electric Code. National Fire Protection Association (NFPA). Publication Number NFPA 70.

Lighting Handbook. Illumination Engineering Society (IES).

NJDOT Design Manual. New Jersey Department of Transportation.

National Electric Safety Code. Institute of Electrical and Electronics Engineers, Inc. Publication C2.

7.2 LIGHTING SYSTEM DESIGN

Lighting systems for Turnpike and Parkway projects will be constructed using the Contract Documents (Plans and Specifications) prepared by various Engineers.

The purpose of this Section, therefore, is to provide the Engineers with general guidelines for the design and preparation of contract documents for Lighting systems, so as to achieve uniform lighting installations between projects.

The Engineer shall advance a lighting design utilizing the following standard process, which is described in detail in this section:

STEP 1 – A Lighting Warrant Analysis shall be performed to assess the need for and requirements of lighting within the project limits. The Lighting Warrant Analysis shall indicate all lighting systems (see below) that may need to be installed.

STEP 2 – Using the results of the completed Warrant Analysis, the Engineer shall determine the specific areas throughout the project that are required to be lighted. Boundaries indicating where lighting shall conform to applicable design standards shall be defined, and the resulting Design Areas shall be used as the basis for lighting calculations. The Engineer shall then determine the design criteria to be used in completing the design.

STEP 3 – The specific type(s) of lighting system equipment to be installed shall be determined. Larger projects may require multiple lighting systems.

STEP 4 – Lighting Calculations shall be performed to determine proper location of lighting equipment.

STEP 5 – The Lighting Plans and Details shall be developed to the Authority's standard requirements.

7.2.1 Lighting Warrant Analysis

This Subsection details the requirements for determining where fixed lighting systems are required to be installed for new construction projects.

A Lighting Warrant Analysis shall be performed prior to any design for each project in order to determine if and where lighting is required for the project. The Warrant Analysis shall be used to determine where new lighting is to be installed and where existing lighting shall remain. If the warrant analysis indicates that existing lighting systems or lighting equipment is no longer warranted, this equipment shall be removed as part of the project work.

The warrant analysis shall be provided for all projects, including those projects that modify existing lighting systems, and shall include the following, where applicable for each project:

1. Determination of the need for any Complete Freeway Lighting
2. Determination of the recommended roadway lighting system for each interchange: Complete Interchange Lighting, or Partial Interchange Lighting
3. Determination of the recommended roadway lighting system for Toll Plazas, Parking Facilities, and/or Storage Areas
4. Areas where existing roadway lighting is no longer warranted, and will be removed
5. Determination of the need for other lighting systems, including but not limited to Underbridge Lighting, Roadway Tunnel Lighting, Sign Lighting, and/or Navigation Lighting

6. Indication of specific areas of the project (hereafter referred to as Design Areas) that will be lighted, and those in which lighting is not required, including specific Stationing if available (See Subsection 7.2.2 for more information)
7. Indication of areas outside Authority jurisdiction that will be lighted by systems that will be maintained by the Authority
8. Indication of areas outside Authority jurisdiction that will be lighted with non-Authority owned-systems but that are being designed and constructed by the Authority, including relevant warrant analysis and design criteria
9. Any special project considerations or additional lighting systems required for the project

The completed warrant analysis shall be submitted concurrently with the Conceptual Illumination Design Plans and shall be included with the Phase "A" Submission. The Phase "B" lighting system design shall not be advanced prior to the Authority's approval of the Engineer's recommendations for lighting system type and extent.

7.2.1.1 Roadway Lighting

Roadway lighting shall be interpreted to include all lighting on areas that are considered "traveled way", that is, areas that carry public vehicular traffic from an origin to a destination.

Roadway lighting shall not be considered warranted solely because it is currently installed on an Authority roadway, ramp, or facility. A separate warrant analysis shall be performed for all roadways, ramps, interchanges, and other facilities within project limits.

The Roadway Lighting Warrant Analysis shall be performed as described in the AASHTO Publication GL-6 *Roadway Lighting Design Guide*, and as excerpted below, with the following Authority-specific requirements:

Continuous Freeway Lighting (CFL)

Continuous Freeway Lighting is a "system [that] provides relatively uniform lighting on all main lanes and direct connections, and complete interchange lighting of all interchanges within the section" (AASHTO, GL-6).

Continuous Freeway Lighting shall be considered warranted only for sections of freeway "where the ratio of night to day crash rate is at least 2.0 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate", (Case Number CFL-4 of AASHTO GL-6) or where required by special project considerations and approved by the Authority's Engineering Department.

Complete Interchange Lighting (CIL)

Complete Interchange Lighting is “a lighting system that provides relatively uniform lighting within the limits of the interchange, including main lanes, direct connections, ramp terminals, and frontage roads or crossroad intersections” (AASHTO GL-6).

If any one of the following conditions (in Exhibit 7 - 1 below) are met, Continuous Interchange Lighting shall be considered warranted and shall be installed for the interchange under consideration

EXHIBIT 7 - 1 WARRANTING CONDITIONS FOR COMPLETE INTERCHANGE LIGHTING

Case	Warranting Conditions
CIL-1	Where the total current ADT ramp traffic entering and leaving the freeway within the interchange areas exceeds 10,000 for urban conditions, 8,000 for suburban conditions, or 5,000 for rural conditions.
CIL-2	Where the current ADT on the crossroads exceeds 10,000 for urban conditions, 8,000 for suburban conditions, or 5,000 for rural conditions.
CIL-3	Where existing substantial commercial or industrial development that is lighted during hours of darkness is located in the immediate vicinity of the interchange, or where the crossroads approach legs are lighted for 0.5 mile or more on each side of the interchange.
CIL-4	Where the ratio of night to day crash rate within the interchange area is at least 1.5 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. Where crash data are not available, rate comparison may be used as a general guideline for crash severity.

Reprinted from Table 3-3 in *Roadway Lighting Design Guide*, AASHTO GL-6, American Association of State Highway and Transportation Officials. October 2005.

Where Complete Interchange Lighting is warranted, the following roadways shall be lighted:

1. Deceleration lanes on the freeway mainline
2. Acceleration lanes on the freeway mainline
3. Ramps and Direct Connections – continuous lighting from the connection to the freeway mainline through their termini at the limits of Authority jurisdiction
4. All Toll Plaza areas within the interchange under consideration
5. Other areas as required by special project considerations

Continuous lighting of the mainline lanes throughout the area of the interchange shall not be provided unless Continuous Freeway Lighting is warranted (see above) or because of other project-specific

considerations. For areas of the mainline to be lighted in the areas of deceleration and acceleration lanes, and merge/diverge/weaving areas, see Subsection 7.2.2.

Partial Interchange Lighting (PIL)

Partial Interchange Lighting is “a system that provides illumination only of decision making areas of roadways including acceleration and deceleration lanes, ramp terminals, crossroads at frontage road or ramp intersections, other areas of nighttime hazard” (AASHTO GL-6).

If Continuous Interchange Lighting is not warranted according to the criteria above, and Case PIL-1, PIL-2, or PIL-3 are met according to Exhibit 7 - 2 below, Partial Interchange Lighting shall be considered warranted and shall be installed for the interchange under consideration:

EXHIBIT 7 - 2 WARRANTING CONDITIONS FOR PARTIAL INTERCHANGE LIGHTING

Case	Warranting Conditions
PIL-1	Where the total current ADT ramp traffic entering and leaving the freeway within the interchange areas exceeds 5,000 for urban conditions, 3,000 for suburban conditions, or 1,000 for rural conditions.
PIL-2	Where the current ADT on the crossroads exceeds 25,000 for urban conditions, 20,000 for suburban conditions, or 10,000 for rural conditions.
PIL-3	Where the ratio of night to day crash rate within the interchange area is at least 1.25 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. Where crash data are not available, rate comparison may be used as a general guideline for crash severity.

Reprinted from Table 3-4 in *Roadway Lighting Design Guide*, AASHTO GL-6, American Association of State Highway and Transportation Officials. October 2005.

Where Partial Interchange Lighting is warranted, the following roadways shall be lighted:

1. Deceleration lanes on the freeway mainline
2. Acceleration lanes on the freeway mainline
3. Ramps terminals
4. Toll Plaza Merge Areas within the interchange under consideration
5. Merge Areas / Lane Drops
6. Decision Points

7. Other areas of nighttime hazard
8. Other areas as required by special project considerations

Bridge Lighting

Continuous roadway lighting shall be considered warranted on long-span bridges (total bridge length in excess of 300 feet) only where both shoulders are substandard. Lighting equipment on existing bridges that have at least one adequate shoulder, or are being widened to have at least one adequate shoulder, shall be removed as a result of project work.

Roadway lighting shall be provided on short-span bridges (total bridge length less than 300 feet) only where required by other warrants in this section – for example, where short-span bridges occur in an interchange where complete interchange lighting is warranted.

Lighting of bridges and overpasses shall be at the same level as the adjoining roadways where practical. See Design Manual Section 2.6 regarding additional design criteria for bridge mounted lighting.

Toll Plaza Merge Areas

All Toll Plaza Merge Areas shall be lighted.

U-Turn and Restricted Access Roadways

Lighting shall not be provided unless directed by the Authority's Engineering Department.

Service Area Roadways

Lighting on ramps to and from service areas, including acceleration lanes, deceleration lanes, and direct connections shall be considered warranted, and shall be installed.

Merge/Diverge Areas

Lighting shall be considered warranted and shall be installed for all merge, weaving, and diverge areas where two major roadways either come together or split. Required lighting of merge and diverge areas shall not be interpreted to warrant installation of lighting on every lane drop and lane add on the mainline, where other warrants in this section are not met. The Engineer shall analyze the requirements for lighting where lanes are added / dropped as described below in the discussion of Special Project Considerations.

Lighting on Roadways of other jurisdictions

Authority-maintained lighting shall be provided on roadways outside Authority jurisdiction only where directed or approved in advance by

the Authority's Engineering Department. Typical situations where lighting on roadways of other jurisdictions may be directed are:

1. On bridges, where the Authority roadway passes over or under a local roadway
2. For safety, where an Authority facility is frequently used by pedestrians
3. Where, by prior agreement, the Authority assumes maintenance of a system as a condition of construction
4. At certain signalized intersections

The Engineer shall coordinate with the Authority's Engineering Department to determine the need for any lighting on roadways of other jurisdictions, and indicate the resolution of this coordination as part of the Phase "A" Submission.

Areas outside Authority jurisdiction

A separate warrant analysis shall be performed on all areas outside Authority jurisdiction where lighting may be installed as a result of project work. Warrant analyses for lighting for roadways and areas under NJDOT jurisdiction shall be performed in accordance with the NJDOT Design Manual. Warrant analyses for local roadways under other jurisdictions, including roadways passing under or over Authority structures shall be performed as per the requirements of the local jurisdiction, or as required elsewhere by this manual.

Special Project Considerations

Additional lighting may be warranted for any of the following project-specific considerations:

1. Roadways with non-standard geometry, tight radii, or visibility concerns
2. Roadway areas with high rates of nighttime accidents, to be determined by analysis of the ratio of nighttime to daytime accidents
3. Areas with excessive merging, weaving, or short sight distances
4. Areas with significant pedestrian traffic
5. Areas with high occurrence of fog
6. Areas where engineering judgment requires adaptation/transition lighting to be installed to prevent unnecessarily abrupt or frequent transitions between lighted and unlighted areas, or areas of different brightness (See AASHTO GL-6)
7. Areas where lighting is required to transition to lighting systems maintained by other jurisdictions (See AASHTO GL-6)

The Engineer shall assess the need for any of these special considerations, and shall make recommendations in the Lighting Warrant Analysis for review and determination by the Authority's Engineering Department.

7.2.1.2 Underbridge Lighting

Underbridge Lighting shall be provided only where roadway lighting is required by other warrants in this Section, but proper lighting levels and uniformity cannot be achieved with ground-mounted lighting standards. This is often due to project-specific geometric considerations such as length of overpass, or orientation of structures relative to various roadways.

7.2.1.3 Sign Lighting

Garden State Parkway

Sign Lighting shall not be provided for any new signs on the Garden State Parkway, unless otherwise directed by the Authority's Engineering Department. Where existing lighted signs are encountered within project limits, the signs shall be replaced with new retroreflective panels, and the sign lighting system shall be removed.

New Jersey Turnpike

1. Unless otherwise directed by the Authority's Engineering Department, sign lighting shall be required for all overhead fixed panel signs and changeable message signs (signs mounted to Span, Butterfly, Cantilever, or Bridge-Mounted Structures – See Section 2 (Structures) and Section 6A (Turnpike Signing and Striping) of this Manual. All other sign types shall not be illuminated, unless directed by the Authority.
2. Where sign lighting is required, the Engineer shall perform calculations for all fixed panel signs within the project, and shall re-analyze any existing lighting to remain where new sign panels are installed on existing structures. If existing lighting does not meet the current design criteria, it shall be removed and upgraded to a system that does meet the requirements.
3. Calculations shall be performed and submitted for every lighted sign, whether or not recommended spacing is shown on the Standard Drawings. Sign lighting shall be designed to the requirements set forth in the *AASHTO Roadway Lighting Design Guide* Publication GL-6. The Engineer shall list in the Phase "A" report the design criteria which will be used for all calculations, and shall submit the calculations with the Phase "B" Submission.
4. There are many existing signs across the Turnpike that do not meet the Authority's current requirements for retroreflectivity (See the Standard Specifications). Where existing substandard lighted signs are encountered within project limits, the signs shall be replaced with new retroreflective panels. The sign lighting system shall be removed if not required for the new sign panel.

5. If lighting is to be maintained on existing structures, the Engineer shall perform a site visit to assess the condition of the equipment and determine whether replacement of the sign lighting is required. A report of this condition assessment shall be included in the Phase "A" report.
6. The Authority's Engineering and Operations Departments are currently investigating a warrant analysis procedure to determine the need for overhead signs lighting on a case by case basis. If directed by the Engineering Department, the Engineer shall perform a warrant analysis for sign lighting for each overhead sign (as described above) in accordance with the following criteria. If the warrant analysis is not required, lighting shall be provided on every overhead sign as described above.

When performing a warrant analysis, lighting shall be warranted for a fixed message sign only if any of the following criteria are met:

- a. Tangent sight distance is less than 1200 feet due to horizontal or vertical curve or other sight obstruction
- b. Sign panels do not meet optimal reflectivity requirements due to older construction methods (button copy, painted signs). This warrant shall not be applicable to new signs, which are constructed with retroreflective sheeting.
- c. "High importance" Guide Signs (i.e. Lane Drops, Changeable Message Signs, or Diagrammatic signs)
- d. Areas with high occurrence of frost or fog
- e. Where directed by the Authority's Engineering Department
- f. Project specific considerations

7.2.1.4 Roadway Tunnel Lighting

A warrant analysis for Roadway Tunnel Lighting shall be prepared in accordance with the *IESNA Recommended Practice for Tunnel Lighting*, Illuminating Engineering Society of North America Publication RP-22-96. In general, "a tunnel is defined as any structure over a roadway which restricts the normal daytime illumination of a roadway section such that the driver's visibility is substantially diminished". Additional daytime tunnel lighting is typically not required for tunnels of length less than 80 feet.

Where tunnel lighting is warranted, supplemented daytime lighting shall be required as directed in RP-22-96. Nighttime light levels in the tunnel shall conform to Authority design criteria, and shall transition appropriately with the roadways on either side of the tunnel.

7.2.1.5 Parking Lot Lighting

Parking Lot Lighting shall be considered warranted, and shall be installed for all parking lots on Authority property, unless directed otherwise by the Authority's Engineering Department.

7.2.1.6 Storage Facilities and Maintenance Yards Lighting

Lighting shall be installed only where directed by the Authority's Engineering Department.

7.2.1.7 Aesthetic Lighting

Aesthetic lighting, which is lighting that is meant to be decorative and not used to illuminate any site, roadway, or facility for safety concerns, shall be installed only where directed by the Authority's Engineering Department.

7.2.1.8 Navigation and Aviation Obstruction Lighting

Navigation Lighting, including channel and fender lights shall be provided on bridge structures with navigable channels as required by the United States Coast Guard or other Federal or Local Regulations. Aviation Obstruction Lighting, including aviation obstruction beacons shall be installed as required by the Federal Aviation Administration.

It should be noted that certain Authority facilities are within airport glide slopes, and may require special treatment to ensure that fixed lighting equipment does not project into restricted air space.

7.2.2 Required Area of Illumination

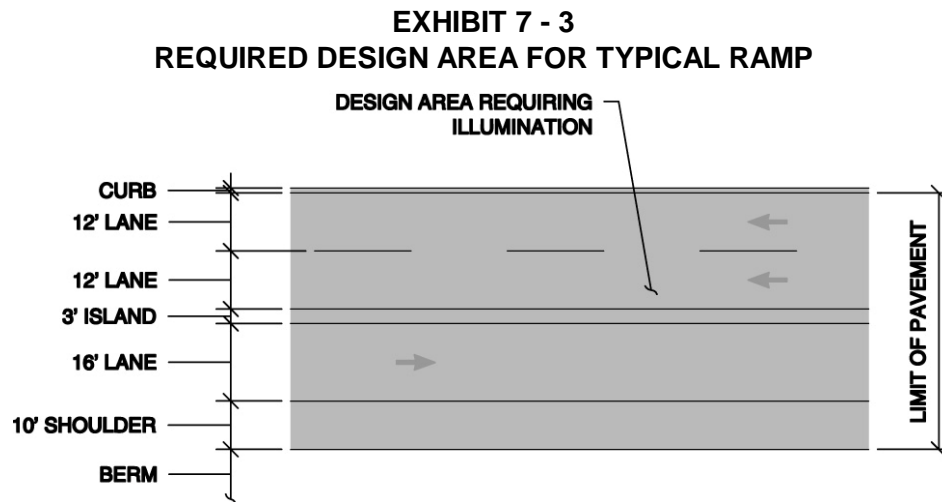
Once the Lighting Warrant Analysis has been completed, the Engineer shall determine the specific project areas that are required to be illuminated. This Subsection is intended to show the methods used to determine the required areas of illumination (denoted as Design Areas hereafter in this Section), where lighting must meet the applicable design criteria. Boundaries shall be defined between the required Design Area(s), and areas where lighting levels will not be analyzed and/or no lighting is required. Lighting levels shall be analyzed only for the Design Areas, as detailed in this Subsection.

The lighting system shall be designed to efficiently and properly illuminate only those areas that require lighting as defined herein. Care shall be taken to minimize spill light into areas that do not require illumination, including both areas inside and outside Authority jurisdiction, unless otherwise directed.

Lighting on all residential areas shall be kept to an absolute minimum. A maximum level of 0.1 foot-candles on any residential properties shall be strictly enforced, unless otherwise authorized by the Authority through the "Design Element Modification" process (see Subsection 7.1.3). The Engineer shall use appropriate luminaire selection and location, and additional shielding or other devices to minimize spill light.

7.2.2.1 Continuous Lighting on Roadways

Continuous lighting on roadways, freeways, ramps, and direct connections, where warranted to be installed, shall be provided from pavement edge to pavement edge. The Design Area shall include all shoulders, medians, curbs, and islands as shown for a typical roadway section in Exhibit 7 - 3 below:



Where lighting is required only on certain portions of the roadway, such as the case of acceleration or deceleration lanes, the other requirements of this Subsection shall apply.

7.2.2.2 Deceleration Lanes

Deceleration Lane lighting, where warranted, shall be installed in advance of the striped gore for the predetermined distance as listed in Exhibit 7 - 6, and continued to a point 30 feet beyond the physical gore. The Design Area shall include the deceleration lane(s) and shoulder, as well as the two adjacent mainline lanes. Lighting shall be provided for a distance of 30 feet beyond the physical gore. Deceleration lane lighting may be extended to accommodate project-specific considerations where directed by, or approved in advance by the Authority's Engineering Department. Deceleration Lane lighting is shown in Exhibit 7 - 4 and Exhibit 7 - 5 below:

EXHIBIT 7 - 4 REQUIRED DESIGN AREA FOR DECELERATION LANE

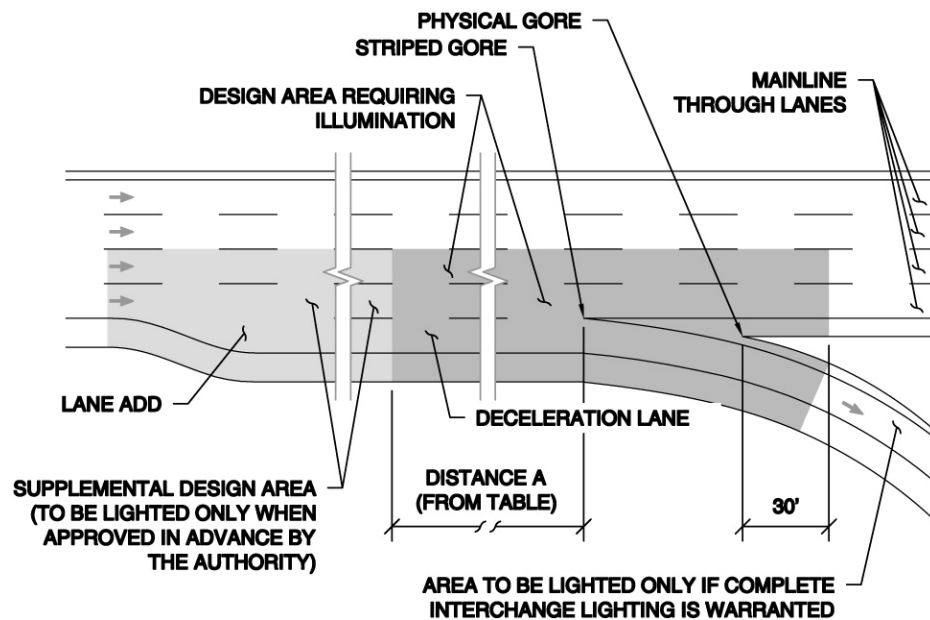
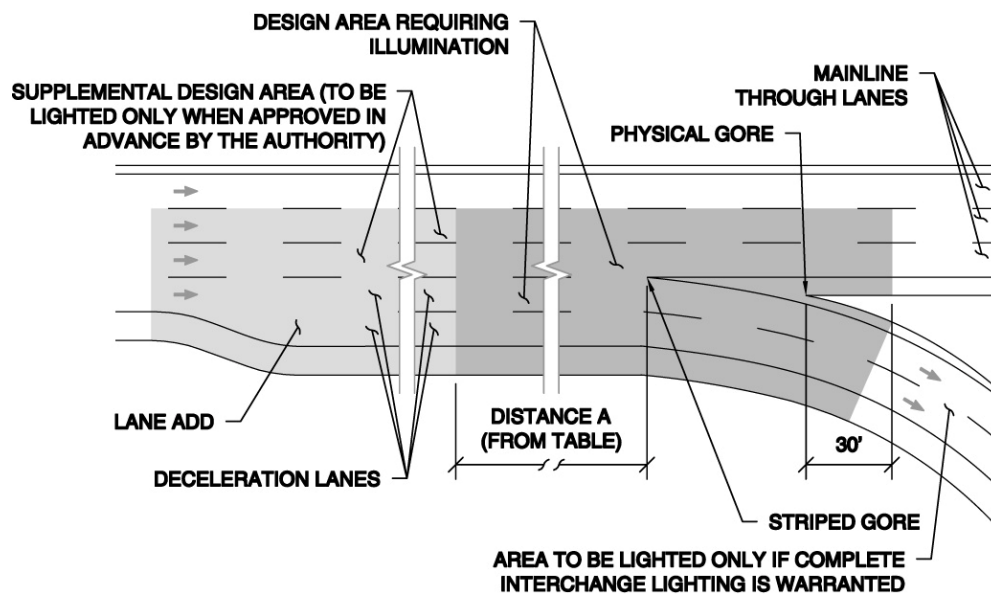


EXHIBIT 7 - 5 REQUIRED DESIGN AREA FOR MULTIPLE DECELERATION LANES



The minimum distance that requires lighting, as measured from the physical gore, is listed below in Exhibit 7 - 6:

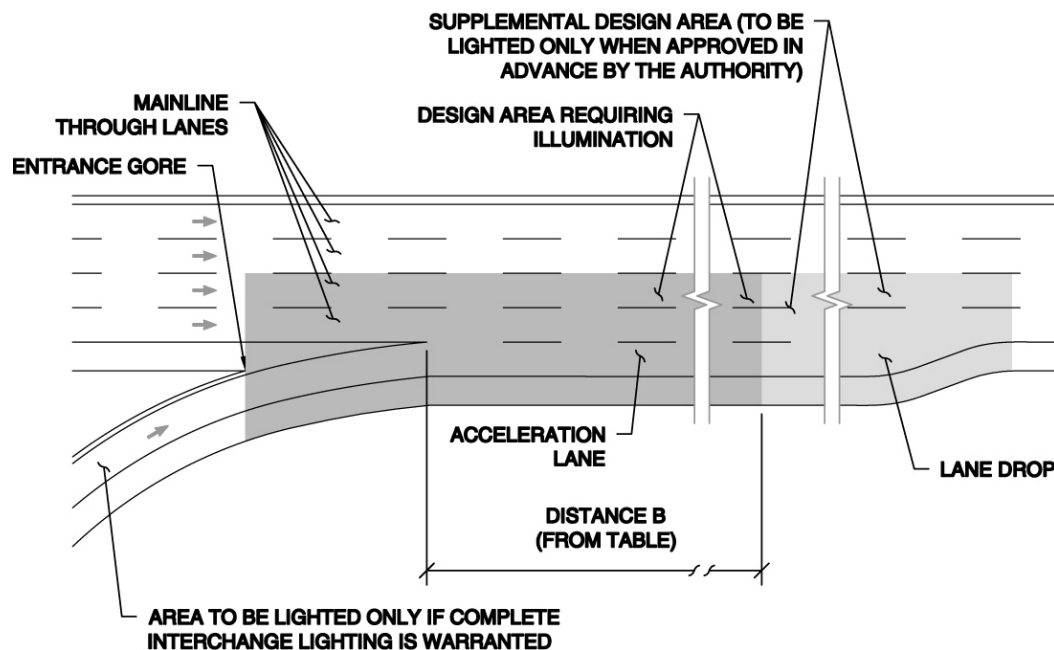
EXHIBIT 7 - 6
TABLE OF DISTANCES FOR DECELERATION LANE LIGHTING

Design Speed Limit	Distance A (Safe Stopping Distance)
35 MPH	250 Feet
40 MPH	325 Feet
45 MPH	400 Feet
50 MPH	475 Feet
55 MPH	550 Feet
60 MPH	640 Feet
65 MPH	735 Feet
70 MPH	835 Feet

7.2.2.3 Acceleration Lanes

Acceleration Lane lighting, where warranted, shall be installed beginning at the physical gore and continuing for a predetermined distance from the striped gore as listed in Exhibit 7 - 8. The Design Area shall include the acceleration lane(s) and shoulder, as well as the two adjacent mainline lanes. Acceleration lane lighting may be extended to accommodate project-specific considerations where directed by, or approved in advance by the Authority's Engineering Department. Acceleration Lane lighting is shown in Exhibit 7 - 7 below:

EXHIBIT 7 - 7
REQUIRED DESIGN AREA FOR ACCELERATION LANE



The minimum distance that requires lighting, as measured from the convergence of the acceleration lane and mainline lanes, is listed below in Exhibit 7 - 8:

EXHIBIT 7 - 8
TABLE OF DISTANCES FOR ACCELERATION LANE LIGHTING

Design Speed Limit	Distance B (Safe Stopping Distance)
35 MPH	250 Feet
40 MPH	325 Feet
45 MPH	400 Feet
50 MPH	475 Feet
55 MPH	550 Feet
60 MPH	640 Feet
65 MPH	735 Feet
70 MPH	835 Feet

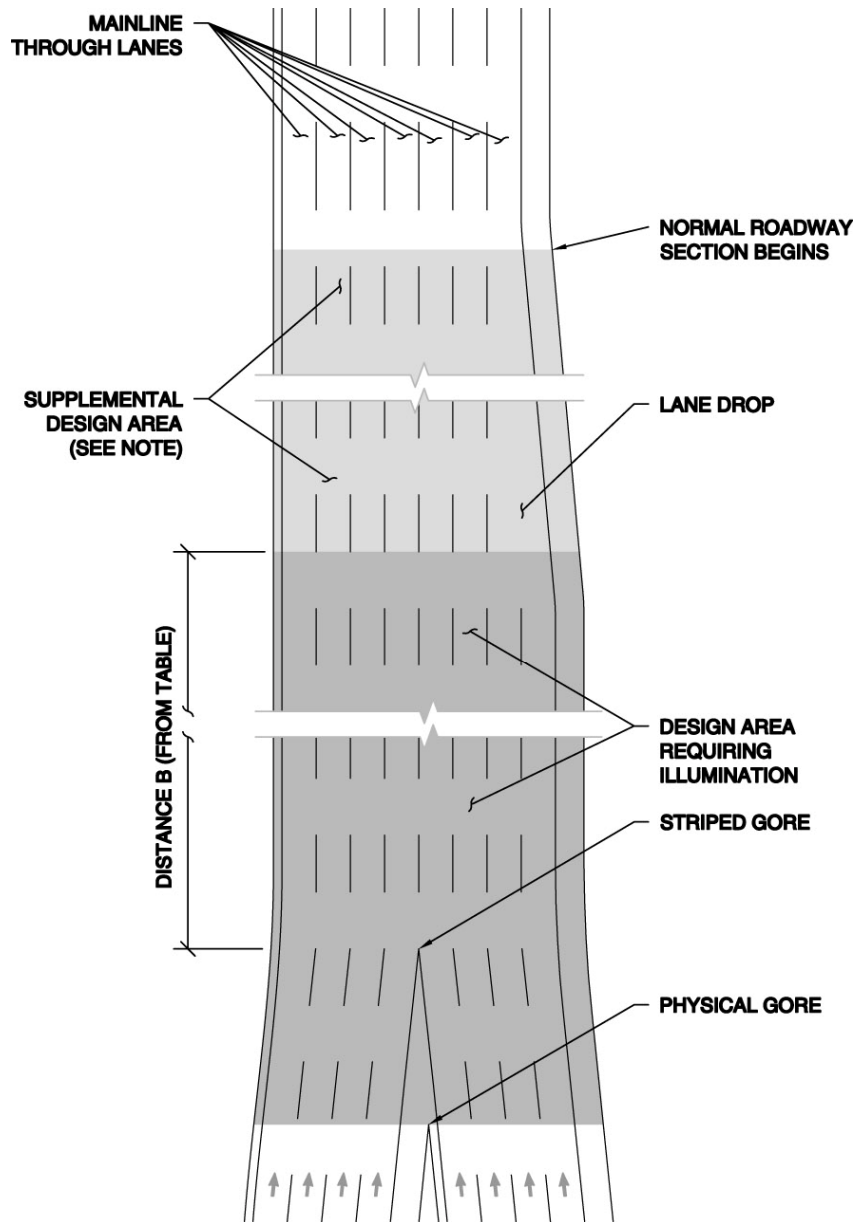
7.2.2.4 Merge, Weaving, and Diverge Areas

Design Areas for merge, diverge, and weaving areas, where lighting is warranted, shall be as shown below in Exhibit 7 - 9 and Exhibit 7 - 10.

The Design Area for merge and weaving areas shall include all paved area starting from the point of the physical gore, to the striped gore, and continuing for a predetermined distance B (determined from the table in Exhibit 7 - 8). If lane drops occur beyond the minimum merge area, the Design Area may be extended to the location where all lane drops have occurred, if directed by, or approved in advance, by the Authority's Engineering Department.

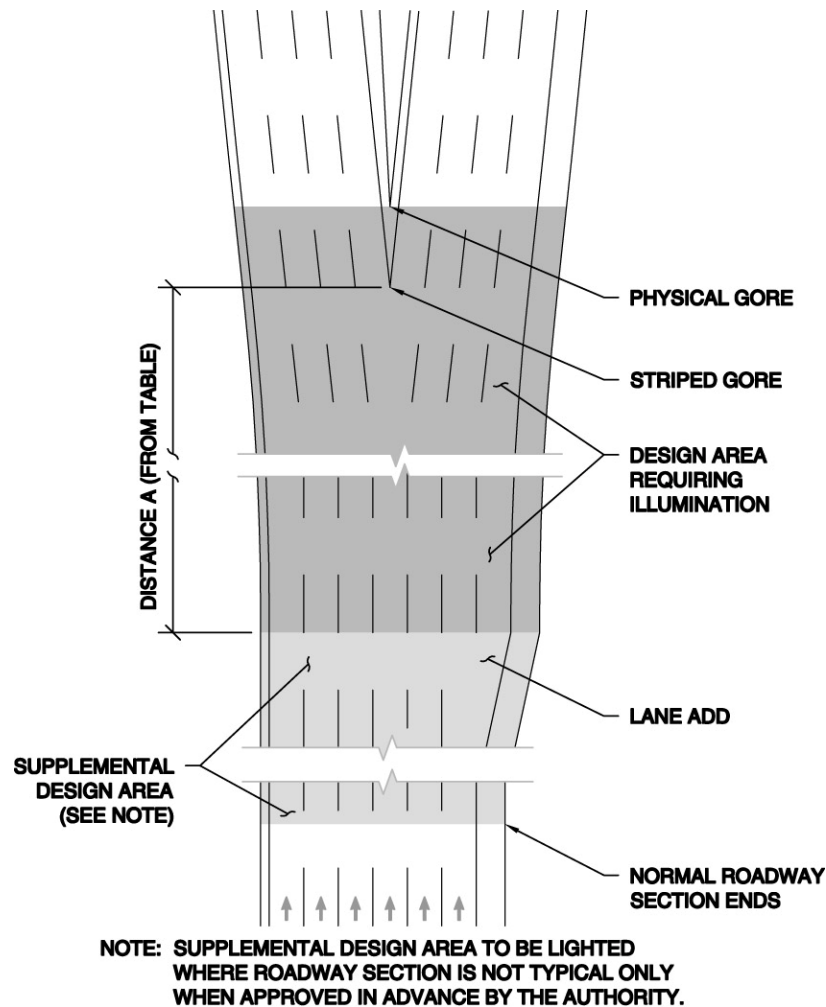
The Design Area for diverge areas shall include all paved area starting from a point located a distance A (determined from the table in Exhibit 7 - 6) from the striped gore, and continuing to the location of the physical gore. If lanes are added in advance of the minimum diverge area for purposes of allowing proper weaving distance prior to the decision point, the Design Area may be extended to a location where the first lane is added if directed by, or approved in advance, by the Authority's Engineering Department.

EXHIBIT 7 - 9
REQUIRED DESIGN AREA FOR MERGE/WEAVING AREA



**NOTE: SUPPLEMENTAL DESIGN AREA TO BE LIGHTED
WHERE ROADWAY SECTION IS NOT TYPICAL ONLY
WHEN APPROVED IN ADVANCE BY THE AUTHORITY.**

EXHIBIT 7 - 10
REQUIRED DESIGN AREA FOR DIVERGE AREA



7.2.2.5 Ramp Termini

Ramp terminus lighting, where required, shall be installed where the ramps connect with local roads, intersections, or other freeways. Because of the diversity of the geometries of the various ramp terminals across the Parkway and Turnpike, the Engineer shall use judgment to determine the necessary Design Area. Any transition lighting necessary to visually connect the Authority's lighting system with the lighting system of another jurisdiction shall be included in the Design Area.

Examples of typical ramp terminus treatments are shown below in Exhibit 7 - 11 and Exhibit 7 - 12 for reference:

EXHIBIT 7 - 11
REQUIRED DESIGN AREA FOR TYPICAL RAMP TERMINUS

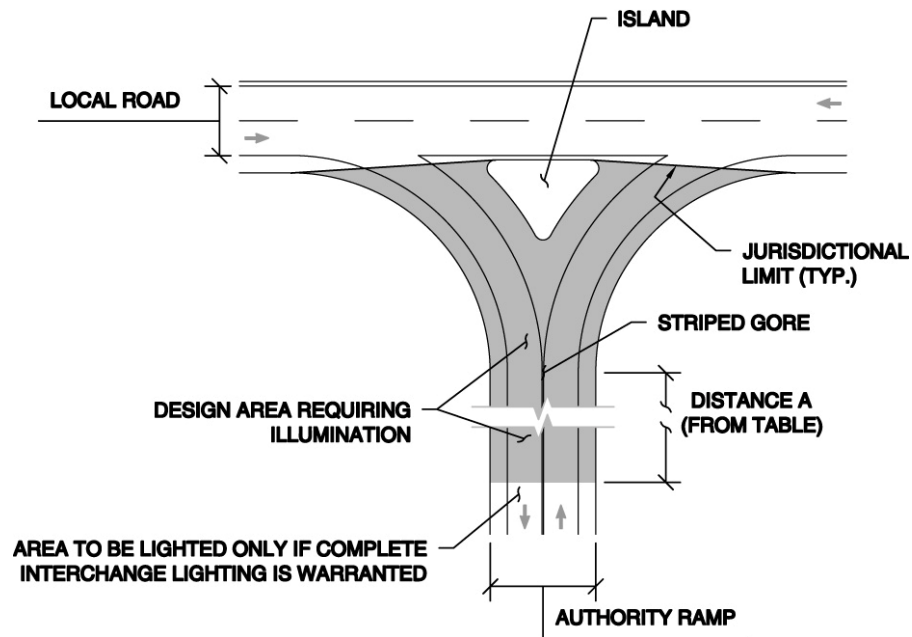
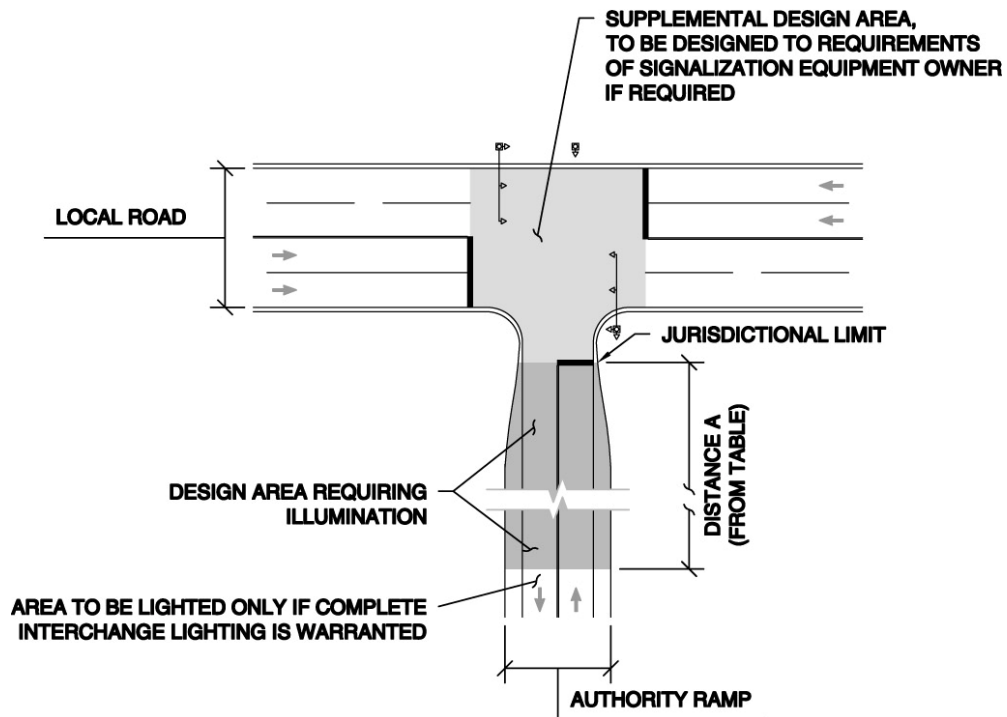


EXHIBIT 7 - 12
REQUIRED DESIGN AREA FOR RAMP TERMINUS AT SIGNALIZED INTERSECTION



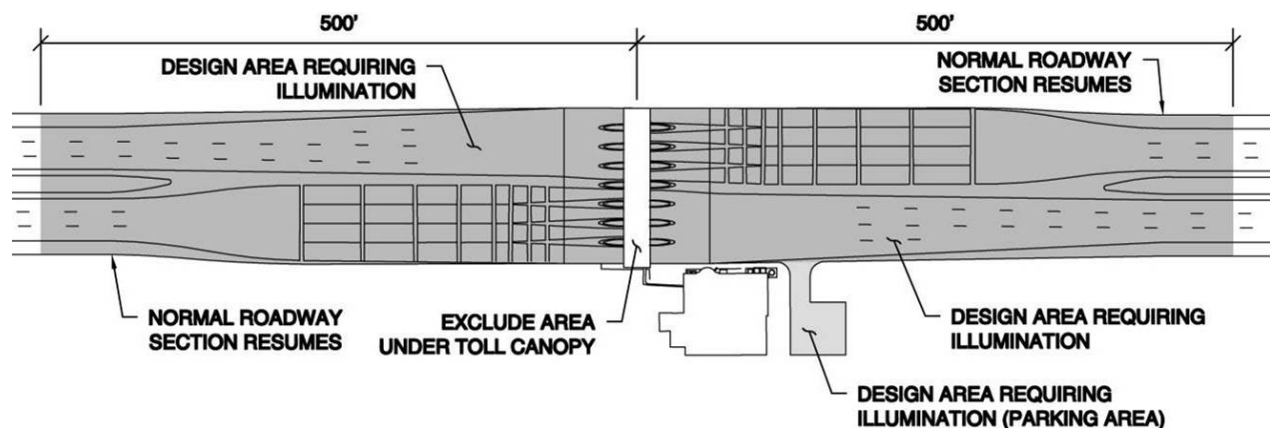
7.2.2.6 Toll Plaza Merge Areas

Toll Plaza Merge Areas (as defined below) shall be continuously lighted from pavement edge to pavement edge, including all shoulders, where required by the Lighting Warrant Analysis. The Design Area for Toll Plaza Merge Areas shall include all islands, dividers, and other obstructions, but shall not include the area immediately below the Toll Plaza Canopy, which shall be analyzed separately.

The Toll Plaza Merge Area shall be defined as the greater of the two following areas:

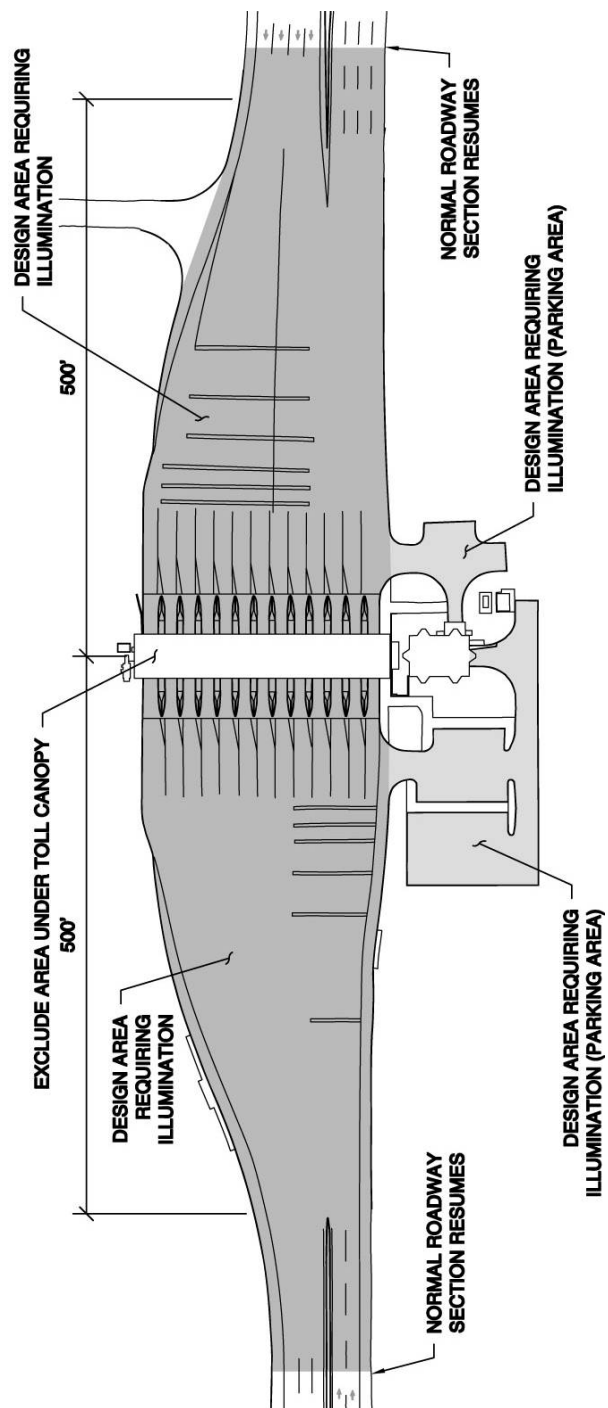
1. The paved area between points located 500 feet on either side of the Toll Plaza centerline as shown below in Exhibit 7 - 13, or

**EXHIBIT 7 - 13
SMALL TOLL PLAZA DESIGN AREA**



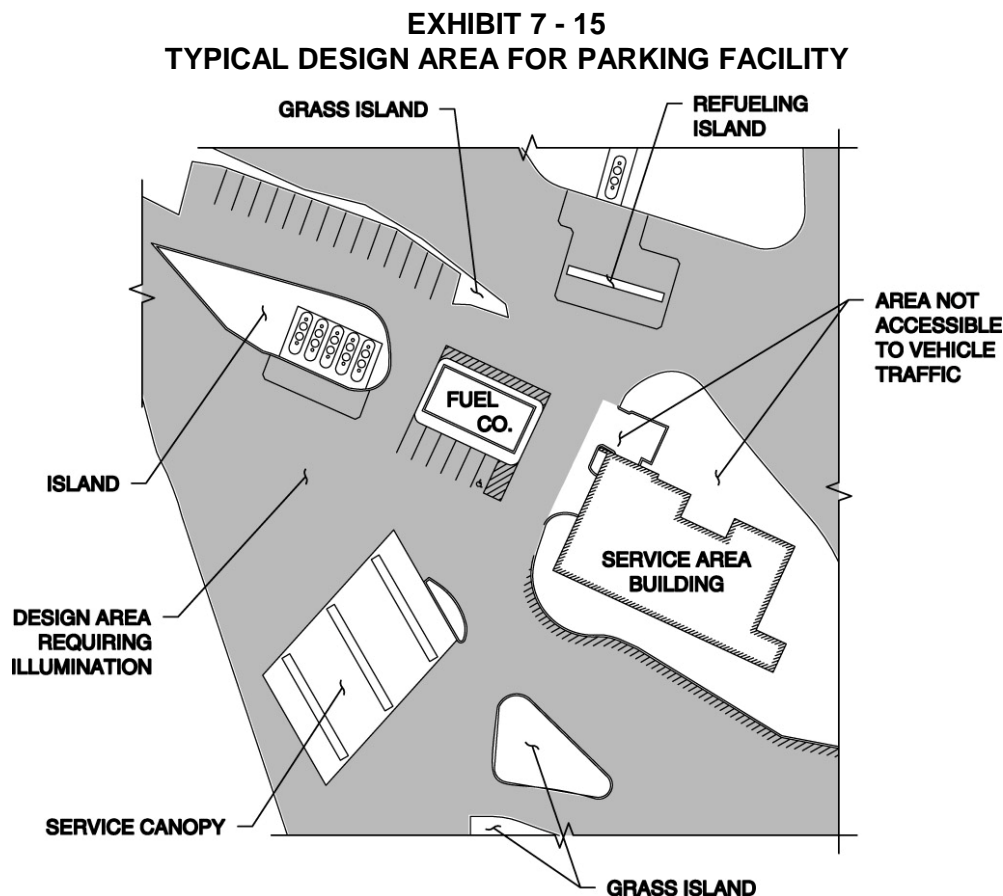
2. The paved area on both sides of the toll plaza that is located between the limits of typical roadway section as shown below in Exhibit 7 - 14.

EXHIBIT 7 - 14
LARGE TOLL PLAZA DESIGN AREA



7.2.2.7 Parking / Maintenance / Storage Facilities

The Design Area for Parking, Maintenance, and Storage areas, where lighting is warranted, shall include all paved area that is accessible by vehicular traffic. Channelizing devices, buildings, islands, service canopies, maintenance buildings, etc. shall be excluded from the Design Area in order to reduce unnecessary light spill and improve overall system efficiency. Areas with any expected pedestrian traffic should be included in the design area to ensure maximum safety. A typical parking area is shown in Exhibit 7 - 15, below:



7.2.2.8 Roadway Tunnels

The Design Areas for Roadway Tunnels, including Adaptation, Transition, and Interior Zones, shall be as defined and described in *IESNA Recommended Practice for Tunnel Lighting*, Illuminating Engineering Society of North America Publication RP-22-96.

7.2.3 Lighting Design Criteria

Once the required areas of illumination (Design Areas) are determined, the appropriate lighting design criteria shall be designated for each area.

The Authority utilizes an Illuminance method for the design of all lighting systems, except as required by the IESNA publications for Roadway Tunnels. Illuminance levels shall be in accordance with the following criteria, shown below in Exhibit 7 - 16:

EXHIBIT 7 - 16
TABLE OF ILLUMINATION AND UNIFORMITY REQUIREMENTS

Usage Classification	Minimum Average Maintained Illuminance (foot-candles)	Maximum Average Maintained Illuminance (foot-candles)	Minimum Point Illuminance (foot-candles)	Maximum Uniformity Ratio (Avg./Min.) ¹
Mainline Roadways and Ramps	0.70	0.85	0.20	4.0:1
Gore Areas (Mainline Roadways and Ramps)	0.70	0.85	0.20	4.0:1
Toll Plaza Merge Area	2.30	2.50	0.60	4.0:1
Toll Plaza Lanes (Area below Canopy)	15.00	20.00	10.00	1.5:1
Major Long Bridges	0.70	0.85	0.20	4.0:1
Service Areas/Parking Areas	1.75	2.25	0.50	4.0:1
Roadway Tunnels	See the <i>IESNA Recommended Practice for Tunnel Lighting</i>			
Other Areas	See the <i>IES Lighting Handbook</i>			
<u>Footnotes:</u>				
¹ Higher uniformity values will be acceptable for elevated ramps near highmast poles, when approved in advance by the Authority				

Light levels for the Toll Plaza Merge Area shall be as listed in Exhibit 7 - 16 above, and shall transition gradually to the light levels of the adjacent roadways near the limits of the merge area.

Toll plaza lanes shall be illuminated on all plazas to the requirements shown. The calculation zone shall be coincident with the projection of the toll plaza canopy onto the roadway surface.

Outside Authority jurisdiction, illuminance levels and appropriate uniformity requirements for roadways and parking areas shall be as determined by the owner of each property or facility. Lighting levels on all local/county/state-owned roadways shall be designed in accordance with the current NJDOT design criteria, unless otherwise directed by the Authority's Engineering Department. At the jurisdictional limits of Authority right of way, all Authority-owned lighting systems shall be designed to transition appropriately to the light levels of the adjacent lighting system, if such system exists.

All lighting calculations shall be performed utilizing a Combined Light Loss Factor (also referred to as Maintenance Factor) to account for degradation of light output due to bulb losses, equipment tolerances, and dirt

accumulation. Light Loss Factors shall be as shown below in Exhibit 7 - 17 for all projects:

**EXHIBIT 7 - 17
TABLE OF LIGHT LOSS FACTORS**

Facility	Light Loss Factor
Garden State Parkway Roadways and Facilities	0.75
New Jersey Turnpike Roadways and Facilities	0.68
Other Authority Facilities	0.75
Other Authority Facilities Considered Dirty ¹	0.68
Local, County, and State (NJDOT) Roadways	Per NJDOT requirements
Other Areas outside NJTA jurisdiction	Per property owner

¹ Area shall be considered “dirty” if environmental factors (i.e. soot, exhaust, dirt, etc.) are expected to accelerate depreciation of lamp lumen output relative to an average installation.

To prevent need to redesign lighting systems, Light Loss Factors shall be determined in advance of, and included with the Phase “A” Submission for review by the Authority’s Engineering Department. See Subsection 7.6.1 for more information.

7.2.4 Selection of Roadway Lighting System

After the various Design Areas and Design Criteria have been determined, the Engineer shall identify the type(s) of Roadway Lighting System(s) to be used on the project. This Subsection details the selection of the Roadway Lighting System only. For information regarding types of equipment installed for other lighting systems, see Subsection 7.3.

Refer to the Standard Drawings and Specifications, and the Authority’s website for references of specific photometric and material requirements, and for a list of currently approved model numbers for each type of fixture as noted below.

7.2.4.1 Approved Roadway Lighting Systems

The Authority currently utilizes and maintains four (4) major types of roadway lighting systems. These systems are designated below, with brief descriptions of the major system features:

1. Highmast Lighting / Floodlighting System – Highmast and Floodlighting systems utilize high-wattage fixtures at mounting heights of 80 or 100 feet, and are designed to light large areas with a minimum of poles. Luminaire wattages used are either 400- or 1000-Watt.

For highmast installations, luminaires shall be arranged in a ring of up to twelve (12) full-cutoff luminaires (useful for symmetrical lighting of areas such as the roadways in a complex interchange). For floodlighting installations, luminaires shall be arranged in a

floodlighting assembly of up to eight (8) floodlighting luminaires that are individually aimed (useful for one-sided and asymmetrical lighting of areas such as toll plaza approaches). Certain legacy highmast and floodlighting systems throughout the roadways utilize poles of different designs that require either climbing or use of a bucket truck for relamping. In all recent systems, the tower poles feature a luminaire ring or floodlighting frame assembly that can be lowered through operation of a winch at the tower pole base, allowing for relamping from the ground level.

All newly proposed tower lighting installations shall utilize lowering devices as shown on Standard Drawing E-xx (to be published at a later date).

2. Pole-Top Cutoff Lighting System – The Pole-Top Cutoff Lighting System utilizes full-cutoff Type P2, P3 or P4 luminaires that are designed to be mounted on poles without the traditional bracket arms. Nominal mounting heights are either 26 or 40 feet, and shall be determined based on the criteria listed in Subsection 7.3.1. Special tenon adapters are installed on the top of each pole, and the luminaire is installed and attached.

The Type P luminaire is preferred by the Authority because maintenance can be performed without the need to shut lanes, as long as the lighting design places luminaires above full-width accessible shoulders. It is preferred to mount luminaires at zero (0) degrees tilt, but some luminaire tilts will be accepted as described in Subsection 7.3.2 or where approved by the Authority's Engineering Department.

3. Conventional Lighting System – The Conventional Lighting System utilizes traditional full-cutoff Type A, B, C and D cobrahead luminaires, mounted on either 8- or 15-foot bracket arms. Nominal mounting heights are either 26 or 40 feet for new installations (30 or 40 feet for retrofit installations on the Turnpike, see Subsection 7.3.1).
4. Offset (Expressway) Lighting System – The Offset Lighting system utilizes non-cutoff Type E fixtures mounted without arms to poles, and oriented such that the luminaires are at an angle to the roadway to maximize the light thrown to the roadway.

The Offset lighting system is ideal for lighting very large areas of roadway; however, it does so at the cost of high glare and spill light. For this reason, the Offset Lighting System shall always be the last system considered for any roadway lighting application.

7.2.4.2 Selection of System

1. For each project, the Engineer shall perform an analysis of project areas and propose the Roadway Lighting System(s) to be installed. The systems should be considered in the following order, which is ranked according to Authority preference:
 - a. Highmast Systems shall be considered first for large, complete interchange lighting systems. A highmast system is ideal for large area lighting applications, where it may offer distinct illumination and economical advantages over the other system types. However, because many Authority roadways are located in close proximity to residential developments and areas with sensitive environmental impacts, it may not be feasible to utilize this system.
 - b. Pole-Top Cutoff System shall be considered the preferred Roadway Lighting System on the Parkway and Turnpike roadways. If a Highmast System cannot be installed due to environmental impacts, the Engineer shall design using a Pole-Top Cutoff System. Pole-Top Cutoff Systems have been installed on roadways and toll plazas as wide as 10 lanes with optimal results, and shall be used for all installations, unless the Engineer can demonstrate that Authority lighting Design Criteria cannot be met.
 - c. The Conventional Lighting System shall be installed only where directed or approved by the Authority's Engineering Department to replace or modify existing Conventional lighting systems that are not slated for complete system replacement.
 - d. Floodlighting Systems should be considered for use only at very wide toll plaza facilities, and shall be considered for use before Offset Lighting.
 - e. The Offset Lighting System shall be considered only where no other system works to illuminate the Design Area to the required light levels and uniformity. Offset type luminaires shall be used for large area toll plazas where conventional cutoff, pole-top cutoff, or floodlighting luminaires cannot provide the required illumination level and uniformity ratio. The Engineer shall make certain that the glare produced by this type of luminaire is properly controlled. Visors and special optical systems may be considered for such applications. The use of Offset type luminaires shall be approved in advance of design by the Authority's Engineering Department. Offset luminaires will not be approved if the area can be lighted by any other means (including Pole-Top Cutoff luminaires mounted at tilts of up to 18 degrees).

2. Multiple different roadway lighting systems shall not be installed concurrently in the same project locations, unless approved in advance by the Authority's Engineering Department. The Engineer shall make every effort to minimize the number of systems and the number of equipment types used at each project location. The only exception to this direction is that Highmast or Floodlighting lighting standards shall be permitted to be installed in the same project areas as other lighting equipment to realize the efficiency gained by these poles when they cannot be used on all areas of a project.
3. Any existing or proposed roadway lighting system and/or equipment that impacts the roadway lighting system under determination shall be considered in the analysis, discussion, recommendations, and calculations.
4. Where projects are performed at locations where existing lighting systems need to be modified in part due to modified proposed geometry or other construction requirements, the Engineer shall consider replacement of all relevant lighting equipment to meet current Authority standards. If replacement is not cost-feasible, or does not offer any material benefit to the Authority, the Engineer shall recommend the exact extent to which lighting equipment shall be removed and replaced.

Where possible, new installations (for example, where all lighting on the ramps from an existing toll plaza to the circuits' terminations on the Turnpike mainline are replaced) shall conform to the current standards of the Authority. If only a small portion of an existing approved lighting system (see Subsection 7.2.4.1 for a list of approved systems) needs to be modified (for example, where several poles are replaced in the middle of a run of existing poles) the new design shall match the standards of the existing installation. See Subsection 7.3.1 for more information regarding types of poles to be used when modifying certain existing lighting installations on the Turnpike.

5. The environmental impacts of each system, especially on residential property, sensitive environmental areas (wetlands, waterways, etc.), and glare / light pollution shall be investigated and detailed in the Phase "A" report. The Engineer shall recommend that any systems with detrimental impacts be eliminated from consideration prior to the Phase "A" submission. After the detrimental systems have been eliminated, the Engineer shall perform a comprehensive cost-benefit analysis of the remaining roadway lighting systems. This cost-benefit analysis shall take into consideration maintenance cost, installation cost, and energy usage, and shall be used in making a

recommendation of proposed Roadway Lighting System. The cost-benefit analysis shall be included in the Phase "A" report.

6. Wood pole systems shall not be allowed, except for temporary construction lighting.
7. Where existing wood pole, non-standard floodlighting, or legacy systems (including systems using standard poles but non-standard fixtures such as offset or vertical lighting luminaires) are encountered during improvement projects, they shall be replaced or upgraded to meet the Authority's current standards of construction, including associated power and distribution systems or other components. This requirement shall supersede the direction given elsewhere in this Section.
8. The Engineer shall perform a separate cost-benefit analysis for the recommendation of any temporary lighting systems, if applicable to the project.

7.2.5 Design Considerations

In the design of lighting systems, the level of light and the effect of glare should be primary concerns. A glare-free environment shall not be compromised in the interest of economy, nor shall higher light levels be permitted where not required by this manual. Special attention shall be exercised to ensure cutoff type luminaires are utilized to the maximum extent possible, that luminaire tilts are minimized, and that consideration to control glare is given to all design applications.

The Engineer shall work to ensure that all lighting designs meet the following basic criteria in order to achieve a superior and economical roadway lighting system. These criteria are presented in order of the Authority's preference (Number 1 being the most important). Where it is not possible to satisfy all criteria for the entire installation due to project-specific constraints, the Engineer shall utilize this ranked list to make decisions regarding tradeoffs between various project elements. Where any of the following criteria cannot be met for a given installation, the Engineer shall include a discussion in the appropriate Phase Submission report, for final approval by the Authority's Engineering Department.

1. Uniform Lighting – The Engineer shall ensure a uniform distribution of lighting intensities that fall within Authority Design Criteria, and shall achieve this throughout the entire system unless specific Design Criteria have been modified through the process described above in Subsection 7.1.3.
2. Responsible Installation – The Engineer shall utilize the most environmentally-friendly solutions that reduce light pollution and ongoing energy consumption.

3. Planned Maintenance – The Engineer shall choose equipment locations that require the least amount of preventative and periodic maintenance in terms of manpower and cost. Equipment locations selected shall be easily accessible for maintenance.
4. Economical Installation – The Engineer shall optimize initial construction costs and ongoing power consumption costs for the entire system.
5. Aesthetically Pleasing – The Engineer shall provide an installation is pleasing and symmetrical in appearance to passing motorists. Lighting installations should not look out of place or be visually objectionable to a public patron who is not trained in the specifics of lighting design, and may not know the engineering reasons why certain options may be preferable if aesthetics are not a consideration. In general, lighting standards shall be aligned or evenly staggered, with relatively uniform height to achieve an acceptable aesthetic appearance. See Subsection 7.3.1 for typical lighting standard arrangements that meet these aesthetic requirements.

It is understood that creating a lighting system design that is compliant with all the above criteria is sometimes difficult, and will require tradeoffs. It will require some judgment on the part of the Engineer to draw an appropriate balance. The Engineer should take this into consideration when determining the required lighting system design.

7.2.6 Lighting Calculation Method

This Subsection lists the specific requirements to be used when performing illuminance calculations for Authority projects. These methods are used for most roadway, site, sign, underpass, and other lighting systems. For details of the luminance calculation methods required for certain Tunnel Lighting installations, see the *American National Standard Practice for Tunnel Lighting* (Illuminating Engineering Society of North America)

Calculations shall be submitted for all areas where Roadway Lighting is warranted, including but not limited to Roadways, Tunnels, Underbridge, Signs, and where Aesthetic Lighting is required for each project.

7.2.6.1 Software and Setup

1. All illuminance calculations shall be performed using the Acuity Lighting Brands, Inc. lighting calculation software called Visual™ Professional Edition, latest version. This is the industry-standard program used for review of lighting calculations. The Engineer may propose use of an alternate lighting calculation program. However, before an alternate program is approved for use on a Project, the Engineer shall furnish the Authority's Engineering Department with three (3) permanent full-service licenses to the program, and shall provide one (1) day of training to three (3) people as designated by the Authority's Engineering Department on the use of the program. Any alternate program used shall be

capable of calculating illuminance based on both direct and reflected components, shall be capable of three-dimensional analysis, and shall utilize a graphical user interface for data input and analysis.

The Visual™ lighting software shall not be used for luminance calculations, as is required for such installations as Tunnel Lighting. The Engineer shall submit for approval a calculation program to be used for all luminance calculations at the time of the Phase “A” Submission. Set up of files and computational methods shall be as described in IESNA RP-22-96.

2. The Engineer shall import the most recent proposed roadway geometry and topographical information into the calculation software, and shall use this as a basis for all calculations. At a minimum, stationing, striping, and utilities shall also be shown. All structures and obstructions which may impact light levels shall be shown, as well as all existing lighting standards that will remain after construction.
3. For complex interchanges, the Engineer shall use three-dimensional modeling and/or creation of obstructions and surfaces within the file to model the effects of bridges, grade-separations, and/or other structures which may interfere with ideal lighting conditions. It shall be permissible to approximate areas of variable grade with multiple stepped “flat” calculation zones, each of as large a size as possible, provided that the method used does not introduce a significant error into the calculations.
4. To reduce coordination and possibility of cross-referencing errors between multiple lighting calculation files, the calculations shall be performed in a single lighting file. If the Engineer desires to utilize more than one file for calculations, a request shall be made to the Authority’s Engineering Department during the Phase “A” Submission. The request shall state the engineering reasons why multiple files are required, and shall be reviewed at the time of the Phase “A” Submission. Any calculations submitted as multiple files without an approved request shall be returned without further review, and resubmission will be required.
5. All calculations shall be performed in U.S. Customary units (lumens, feet, foot-candles).

7.2.6.2 Calculation Zones

1. Calculations zones shall be defined to be coincident with the lighting Design Area, (See Subsection 7.2.2 for determination of Design Areas). Calculation zones shall be constructed using the Polygon method, and shall closely match all curved geometry of

the base drawing to ensure that no calculation points are unintentionally omitted. Each section or Design Area shall be analyzed using a separate calculation zone, and multiple calculation zones shall be allowed for each Design Area. Use of statistical zones shall not be permitted. Calculation zones shall be defined as large as possible given the above criteria for ease of design and review.

2. In order to facilitate review of the calculations, calculation zones shall be named to match the area being calculated, or roadway station points. Multiple colors shall be used to differentiate between zones. Minimum and maximum values shall be displayed in a different color than the main calculation zone points.
3. Calculation zone accuracy shall be set to hundredths (double-digit decimal "0.00" accuracy). Point spacing for all calculation zones shall be 5 feet transversely and longitudinally.
4. Calculation zones shall be defined for all residential lots, and shall be named "Residential Area". Lighting levels in these areas shall be kept to a maximum illuminance of 0.10 foot-candles (see Subsection 7.2.2). If more than one residential area exists, or if residential areas are separated such that they cannot be defined as one area, then each residential area shall be numbered logically following "Residential Area 1", "Residential Area 2", etc.
5. Masking or deletion of individual calculation points shall not be permitted. The only exception is that masks will be allowed for large parking areas – for example, to exclude a gas station or building from the overall calculation zone.

7.2.6.3 Luminaires and Photometrics

1. Luminaire definitions shall be created using the approved .IES photometric files shown on the Standard Drawings, and as otherwise directed by the Authority's Engineering Department. Photometric data used shall be the most recent version of files approved by the Authority's Engineering Department. The most recent version of the photometric files and corresponding documentation are available on the Authority's website for use in project designs.
2. IES photometric files used in calculations for existing and/or proposed non-Authority or non-standard equipment shall be as per the manufacturer's direction for the specific equipment. Manufacturer, fixture type, and photometrics shall be determined by field investigation, review of As-Built plan, coordination with equipment owner, or similar method. "Approximate" photometrics files will not be accepted.

3. Tilt values and optical rotations in the luminaire definition shall be set to zero degrees in the luminaire definition. All tilts shall be applied to the individual luminaires / light standards.
4. Mounting height of luminaires shall be the actual mounting height as shown in the Standard Drawings, rounded to the nearest foot to simplify data entry.
5. Symbols in the Luminaire Schedule shall be defined accurately and to scale. Arm lengths, where required for each Lighting Standard, shall be defined to match those shown on the Standard Drawings.
6. Luminaires / Lighting Standards shall be laid out in accordance with the details shown on the Standard Drawings and to match the design considerations listed in Subsection 7.2.4.
7. The Engineer shall ensure that the location and types of luminaires and lighting standards are consistent between all calculations files and the plans developed for construction of the lighting system.
8. All light sources within three (3) mounting heights of any calculation zone shall be included in the calculations. This includes all light sources, including utility, site, and other lighting that is not on Authority property. For example, if a utility light on a 30-foot pole is near Authority property, it shall be included in the design as a contributing light source if it lies within $3 \times 30 = 90$ feet of any calculation zone.
9. Exhibit 7 - 18 below indicates the initial lamp lumens of various High Intensity Discharge (HID) lamps that shall be used when defining light sources within the calculation software. These lumen values should be used even if the .IES photometric files are imported with different (manufacturer specified) values. Only clear lamps shall be utilized on Authority projects. Lumen values for lamps of other types that are used in calculations shall be as reported by the manufacturer of the lamp. Metal Halide lamps shall be appropriately derated if used in orientations that degrade the lumen output.

EXHIBIT 7 - 18
LAMP TYPES, WATTAGES, LUMENS, AND RATED LIFE

Lamp Type			Lamp Watts	Initial Lumens	Rated Hours
High Pressure Sodium (HPS)			70	6,400	24,000
			100	9,500	24,000
			150	16,000	24,000
			200	22,000	24,000
			250	27,500	24,000
			310	37,000	24,000
			400	50,000	24,000
			750	Not approved	
			1000	140,000	24,000
Mercury Vapor (MV)			100	3,800	24,000
			175	8,000	24,000
			250	11,200	24,000
			400	21,000	24,000
Metal Halide (MH)			175	14,000	20,000
			250	21,500	20,000
			400	37,500	20,000
			1000	110,000	12,000

7.2.6.4 Additional Considerations

Calculations shall be performed using all approved photometrics for a given fixture type. Where there is more than one manufacturer of a particular luminaire, the Engineer shall submit calculations proving that the lighting standard and luminaire locations result in light levels that meet Authority design criteria for all approved manufacturers. For example, if there are four (4) approved manufacturers of the Type P2 pole-top full cutoff luminaire, the Engineer shall submit four calculation files (one file showing the fixtures of each manufacturer) that are identical in all regards except for the photometrics used for the fixtures, and all calculation files shall indicate compliance with Authority design criteria.

The above design approach ensures that the Contractor may provide any of the approved luminaires without compromising the quality of the final system's lighting values and uniformity.

Calculations shall also be provided for each stage of construction, where temporary roadways or lighting systems are in use.

7.2.6.5 Verification of Lighting Design

After the completed lighting system has been constructed, the Engineer shall perform a verification of the lighting installation to ensure that the lighting has been installed according to the design. This verification is required before the Authority issues final acceptance for any lighting system.

Procedure

The Engineer shall overlay a grid with a maximum point spacing of 50 feet on a site plan of all lighted areas, and shall take light readings at each point. A plan of actual light reading values shall be created and compared to the computerized calculations prepared for project design, using a Light Loss Factor of 1.00 (at initial installation, lighting has not yet depreciated). If any discrepancies are found in the light readings in the field as compared to the design values (average, uniformity, minimum values), the Engineer shall determine the source of discrepancy and recommend a course of action to the Authority's personnel in charge of Construction oversight. The Engineer shall repeat the light readings and Contractor coordination until satisfied that the installed system(s) match the lighting design. Typical issues causing non-compliance of installed system that have been encountered in the past are improper aiming of floodlight luminaires, and incorrect tilts on fixtures.

After any problems are reconciled, the Engineer shall then submit two (2) copies of the following to the Authority for release of the lighting system:

1. Plan showing actual light values for all lighted areas in the project, with readings taken at a maximum of 50 foot point spacing
2. Full-size color prints at the same scale as the light-reading plan, showing the theoretically derived lighting levels with a Light Loss Factor of 1.00.
3. A signed and sealed letter verifying that the lighting system was installed to design, and that the light levels are within satisfactory tolerances.

7.3 LIGHTING EQUIPMENT AND MATERIALS

7.3.1 Roadway Lighting Standards

Except for Highmast and Floodlighting Systems, lighting standards shall be aluminum alloy, equipped with single, twin or double tenon bracket arms or luminaire mounting adapters, and mounted on shoe or transformer bases. Ground-mounted lighting standards are typically mounted on precast concrete bases or Junction Box Foundations. Bridge/wall/structure-mounted lighting standards are mounted either on either a parapet blister mount – See Structural Standard Drawing BR-15 – or using the Parapet Mounting Brackets for Retrofit installations on the Turnpike only.

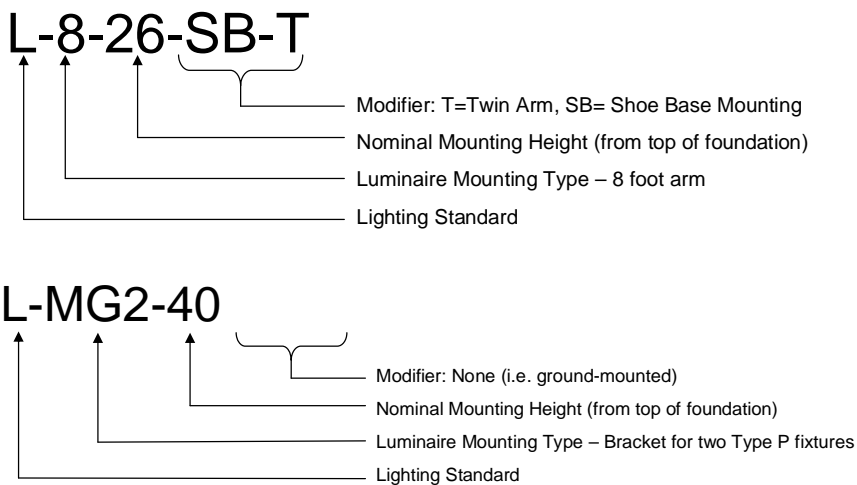
All light poles shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. See Section 2 (Structures) of this Manual, and specific information on the Standard Drawings for more information.

For specific types, descriptions, and dimensional details of approved Lighting Standards, refer to the Standard Drawings.

The Turnpike, for many years, utilized 30 and 40-foot poles of a design that is different from that historically used on the Parkway. These poles are designated with numeric types – i.e. “Type 1”, “Type 2”, “Type 3”, etc. that are standardized across the roadway, and shall be proposed for Retrofit installations only (i.e. to replace/interface to existing systems on the Turnpike). The details for the Retrofit Lighting Standards are shown on the Standard Drawings ER-xx through ER-xx (to be published at a later date).

The new “E” Standard Drawings (to be published at a later date) have been updated to reflect the Authority’s decision to utilize the NJDOT-style poles that historically been used on the Parkway. The poles feature clamp-on arms and standard 26 and 40 foot nominal mounting heights and shall be used on all new construction projects unless noted otherwise. These poles are designated with a coded system, which is shown below in Exhibit 7 - 19. There are many combinations that have been pre-approved for use on Authority projects. For a complete list of these types, see the Standard Drawings (to be published at a later date).

EXHIBIT 7 - 19 LIGHTING STANDARD DESIGNATION METHOD



The NJDOT-style poles are shown on Standard Drawings E-xx through E-xx (to be published at a later date), and shall be used on all Parkway projects, as well as projects on the Turnpike where all of the following criteria can be met, or where directed by the Authority:

1. A continuous portion of a circuit is being replaced, from a point in the center of a circuit to a point either at the circuit terminus or at the source of power.
2. At least 4 poles are being replaced.

3. The installation of the “new-style” poles as shown on Standard Drawings E-xx through E-xx (to be published at a later date) will not result in an objectionable aesthetic appearance.

It is recognized that certain projects on the Turnpike will only modify small portions of existing lighting installations. Where not replacing substantial portions of light systems, use of the Retrofit lighting standard types shown on Standard Drawings ER-xx through ER-xx (to be published at a later date) shall be permitted by prior approval of the Authority's Engineering Department.

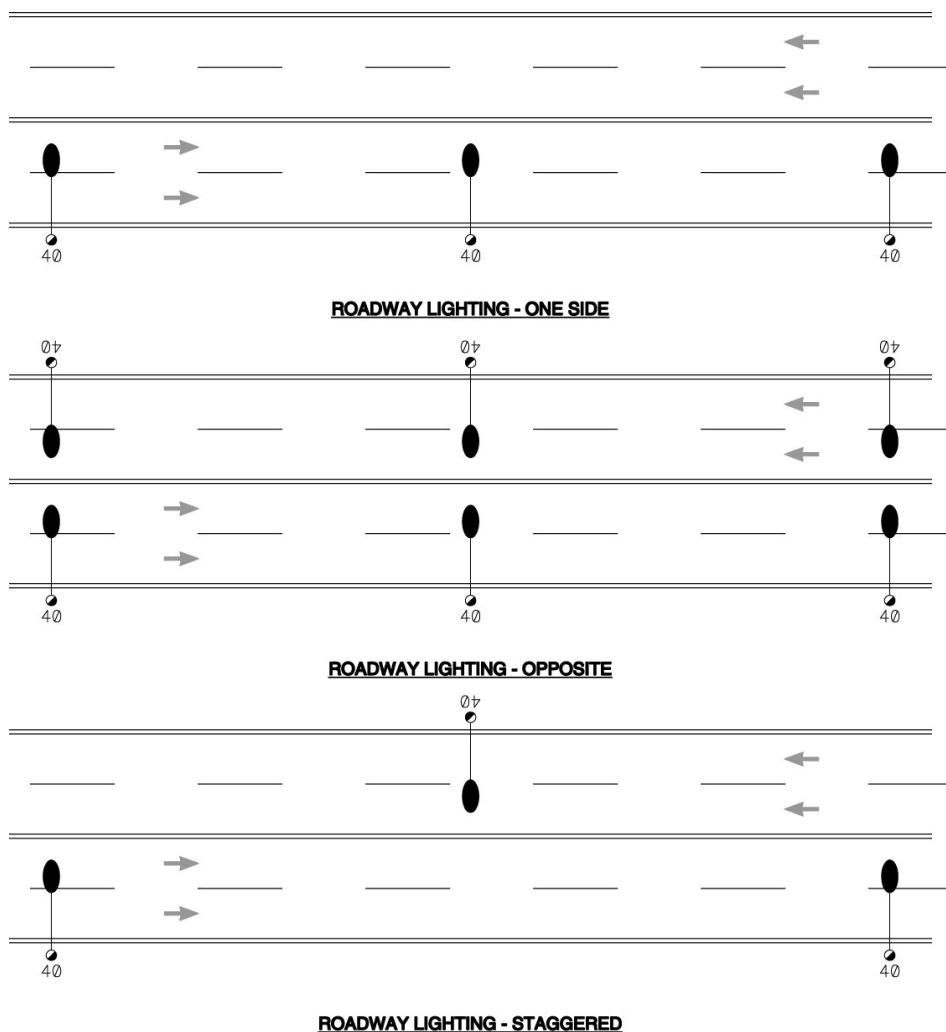
Where non-standard poles are approved for use by the Authority's Engineering Department according to other requirements in this Section, the poles shall be designated with the Modifier “NS1”, “NS2”, etc. for each type of non-standard pole used on a project. The details and model number information for all non-standard poles shall be clearly shown in the Plans. For example, a painted steel aesthetic parking lot lighting pole with 20 foot height and 4 foot arm would be designated “L-4-20-NS1.” A pole of the same construction, but with 25-foot height would be “L-4-25-NS1”. A twin arm pole would be “L-4-25-NS1-T”, etc.

Type, arrangement and location of lighting standards to be used in various areas shall conform to the following design criteria:

1. For pole-top cutoff lighting installation, “L-MG” type lighting standards with 26 foot and 40 foot nominal mounting heights shall be used for ramp and mainline roadway illumination. 40-foot poles with 150 and 250 Watt Type P luminaires shall be considered for use first, in order to yield a more efficient design. 26-foot poles and/or 100 Watt fixtures shall be permitted on roadways up to 30 feet wide, provided that the Design Criteria are met and the Engineer can justify their use in lieu of 40-foot poles because of specific project-related constraints, efficiencies, or impacts to non-Authority property. 400 Watt fixtures shall be used only for very wide roadways or where the Illumination Design Criteria is greater than 1.0 foot-candles.
2. For conventional system installations, lighting standards with 26 or 40 foot nominal mounting heights (and 30 foot heights where retrofit poles are approved) shall be used for ramp and mainline roadway illumination, equipped with Type A, B, C or D luminaires.
3. Offset (expressway) lighting standards Types L-E-48, L-E2-48 and L-E3-48, as shown on the Standard Drawings (to be published at a later date) with 48 ft. nominal mounting height and equipped with offset luminaires shall be used only in toll plaza areas and certain other areas of wide geometry. Use of these Lighting Standards shall be approved in advance by the Authority's Engineering Department.
4. Bridge-mounted or parapet-mounted lighting standards shall be permitted to be 26, 30 or 40-foot nominal mounting height.

5. Lighting standards shall be arranged in one of the following three (3) methods; one-sided, opposite, staggered. An illustration of these arrangements follows in Exhibit 7 - 20. Selection of the method shall be based on the engineering analyses shown to produce the most effective and economical lighting system. The Engineer shall analyze both installation methods to determine the recommended scenario, and shall describe the analysis as part of the submission report. Except where non-symmetrical geometry is encountered, lighting shall be evenly spaced and staggered to yield a pleasing visual appearance. See Subsection 7.2.5 for more information regarding aesthetic treatment of lighting installations.

EXHIBIT 7 - 20
TYPICAL ROADWAY LIGHTING STANDARD ARRANGEMENTS



6. Lighting standards shall be located along the wide shoulder (10 ft. and 12 ft.) edge of all ramps and mainline roadways in order to facilitate maintenance and re-lamping. In very wide gore areas, however, it shall

be permissible to install a small number of supplementary lighting standards along the opposite shoulder in order to achieve illuminance requirements.

7. When a lighting standard is to be located within the vicinity of an exit gore area, a minimum of 50 ft. clearance should be provided beyond the physical bullnose.
8. Lighting standards adjacent to overpasses shall be located to avoid glare affecting traffic on overpasses. Additionally, light cutoff angles produced by structural members should be analyzed when locating such lighting standards. Preferably, the lighting standards should be located equidistant from overpass structures. If this cannot be achieved, a minimum clearance of 35 feet (for 26- and 30-foot poles) and 50 feet (for 40-foot poles) shall be provided from the face of parapet of a typical overpass (with standard minimum vertical clearance).
9. Lighting standards adjacent to overhead sign structures should be located equidistant from such structures, if feasible, otherwise minimum clearance requirements set forth for the overpass structures shall be provided.
10. Opposite lighting standard arrangements (see Exhibit 7 – 20) shall be used in toll plaza areas, except at certain narrow toll plazas where required illuminance levels and uniformity ratios can effectively be achieved by one-sided arrangement.
11. Ground-mounted lighting standards shall be installed on concrete bases or Junction Box Foundations. Junction box foundations shall be used in lieu of junction boxes and separate concrete bases wherever feasible. Each lighting standard installed on a concrete base shall be provided with a concrete junction box adjacent thereto for cable splicing, unless another junction box within the proximity of the lighting standard (up to 50 feet away) can be used for this purpose.
12. Lighting standards on bridge structures shall be located near piers or abutments in order to reduce undesirable vibration affecting the lamp life. Mid-span locations must be avoided whenever possible. See Section 2 (Structures Design) of this Manual for specific locations where lighting standards are allowed. All bridge-mounted light standard mounts shall be capable of supporting all standard Authority poles, up to a height of 40 feet.
13. Lighting Standards shall be installed such that they are located not closer than 20 feet to primary or secondary utility power lines or communication facilities that are mounted to wood or other utility poles. The Engineer shall take into consideration the requirements of the National Electric Safety Code when designing lighting systems in the vicinity of power distribution lines. Additionally, the Design shall take into consideration the likelihood of pole knockdowns by vehicle impact, and

ensure that no other critical facility may be rendered inoperable in the event of an accident.

14. The number of various lighting standard assemblies and fixture optics shall be kept to a minimum on each project, for ease of maintenance. Runs of adjacent lighting standards shall be of the same type or fixture. The Engineer shall not alternate lighting standards types, luminaires, or wattages, or install small quantities of non-matching lighting standards in a string of otherwise identical poles, unless there is a valid engineering reason why such a design is required in lieu of other, more standardized designs.

7.3.2 Roadway Lighting Luminaires

Various types of luminaires to be used for roadway lighting systems shall be as shown on the Schedule of Approved Luminaires in the Standard Drawings (to be published at a later date).

All standard luminaires are designated by a one or two digit letter-number combination, i.e. "Type A", "Type E", or "Type P2" independent of fixture wattage, which shall be shown separately on the Plans. Where non-standard luminaires are approved for use by the Authority's Engineering Department according to other requirements in this Section, the luminaires shall be designated as Type "N1", "N2", etc. for each type of non-standard luminaire used on a project. The details and model number information for all non-standard poles shall be clearly shown in the Plans. For example, a 250 Watt aesthetic parking lot lighting fixture would be designated "Type N1". A fixture of the same construction, but with 400 Watt lamp would also be designated "Type N1" (however, the Plans would show the appropriate wattage). A fixture of different construction used on the same project would be "Type N2", etc.

Descriptions on the use of each type of standard luminaire follow. Where multiple photometrics are approved for use in a given installation (for example, when choosing between the P2 and P4 fixtures), the Engineer shall perform calculations for each type to determine the optimal solution for the given Design Area.

1. Conventional luminaires (Type A, B, C or D) to be used for general roadway, toll plaza and parking area illumination shall be full cutoff units of types and sizes listed in the Standard Drawings and Specifications. The photometric requirements for cutoff luminaires shall be in accordance with Standard Drawings. While there are existing luminaires of other wattages installed across the roadways, luminaires of 150, 250, and 400 Watts shall be utilized in all new designs only. Special permission may be given for 100 Watt luminaires if the Engineer can justify their use on a project to achieve the Authority's Design Criteria.

In general, lighting standards with 26/30 foot mounting height shall be used for ramp roadway illumination, and lighting standards with 40 foot

mounting height shall be used for mainline roadway illumination. However, 26/30 foot lighting standards may be used for roadways up to 36 feet wide, where existing 26/30-foot lighting systems are required to be modified. The Engineer shall perform calculations to determine the optimal pole height for any given installation.

2. Special architectural type luminaires may be utilized, as approved by the Authority, for Service Area applications.
3. Pole-Top Cutoff luminaire photometric requirements for Type P2, P3 and P4 luminaires shall be in accordance with Standard Drawing E-xx (to be published at a later date). Use of the luminaires shall be as follows:
 - Type P2 – Mongoose with Flat Glass and Narrow reflector (IES Type I/II) optics
 - Type P3 – Mongoose with Flat Glass and Wide roadway reflector (IES Type III) optics
 - Type P4 – Mongoose with Flat Glass and Forward Throw reflector (IES Type IV) optics

The following chart in Exhibit 7 - 21 summarizes the photometrics that shall be used for designs on both the Parkway and Turnpike, and gives recommendations where and how each type of luminaire should be used. Because of the variety of project geometrics, it is expected that these recommendations may have to be adapted for some projects. The Engineer shall perform calculations using the guidelines below to determine the optimal lighting equipment and layout based on the other parameters and requirements of this Section.

EXHIBIT 7 - 21
TYPE P LUMINAIRE INSTALLATION GUIDELINES

TYPE	LAMP WATTS ²	IES DIST. TYPE	OPTICS TYPE	NOMINAL MOUNTING HEIGHT	RECOMMENDED USE
P2	100	I	Narrow Roadway	26'	Ramps and Bridges < 30' in width ⁴
P2	150	I	Narrow Roadway	26' / 40'	Design Areas < 48' in width
P2	250	II	Narrow Roadway	40'	Design Areas < 48' in width
P2	400	II	Narrow Roadway	-	Not approved
P3	150	III	Wide Roadway	-	Not approved
P3	250	III	Wide Roadway	40'	Special geometry ¹
P3	400	III	Wide Roadway	40'	Toll plazas and special geometry ¹
P4	150	IV	Forward Throw	26' / 40'	Special geometry ¹
P4	250	IV	Forward Throw	40'	Design Areas > 60' in width
P4	400	IV	Forward Throw	40'	Toll plazas, double & triple installations ³

Footnotes:

* All luminaires are Flat Glass, Full Cutoff, Clear High Pressure Sodium (HPS)

¹ Luminaire to be used in areas of non-standard geometry, varying widths, or transitions between light levels, and only when other approved fixtures do not work. Use shall be approved in advance by the Authority.

² Lamp wattage (in Watts) does not include ballast losses.

³ A tilt of no more than 5 degrees shall be allowed for all luminaires. Greater tilt angles shall be utilized only with an approved modification of Design Criteria (See Subsection 7.1.3). A tilt of up to 18 degrees shall be allowed for Type P4 – 400 Watt luminaire where required if no full-cutoff (5 degree tilt max) solution can be made to work.

⁴ 100 Watt fixtures to be used only where 150 watt luminaires are proven ineffective to meet NJTA Design Criteria as established herein, and approved in advance by the Authority's Engineering Department.

4. Offset luminaire photometric requirements for Type E offset luminaires shall be in accordance with the Standard Drawing.
5. Additional luminaire requirements shall be as described elsewhere in this Section.
6. Mercury Vapor lamps shall be specified only where maintaining existing lighting systems, or where required to be installed in accordance with the Standard Drawings or Specifications. High Pressure Sodium lamps shall be utilized for all roadway lighting applications, except as directed by the Authority's Engineering Department. Metal Halide lamps shall be used in all parking lot lighting systems, and shall not be used for any systems that require a 24-hour on-time, as the lamps are required to cycle on-off for optimal lamp life.

7.3.3 Highmast and Floodlighting Systems

1. Highmast and floodlighting systems shall utilize 80- to 100-foot-high galvanized steel towers equipped with six to twelve 400 or 1000 watt

HPS luminaires as shown on Standard Drawing E-xx (to be published at a later date), as outlined in the Standard Specifications, or as otherwise approved by the Authority's Engineering Department. The number and types of fixtures provided on a given project shall be kept to a minimum.

2. Highmast and Floodlighting Lighting Standards shall be located free of the clear zone (usually 30 feet on most roadways) or protected by physical obstruction or a raised foundation.
3. Use of 750 Watt luminaires shall be avoided due to excessive cost of these lamps relative to lamps of other wattages.
4. Unless otherwise directed, all Highmast and Floodlighting poles in excess of 50 feet shall be designed with lowering devices, a bottom-latching chain assembly, lightning protection, proper grounding, guide rollers to prevent swaying while the luminaires are being lowered, and a method to safely prevent the ring or floodlighting assembly from rotating or moving unexpectedly when lowered for relamping.
5. Proper aiming of each fixture, including orientation angle, tilt angle, and appropriate reference angle information, shall be included in the plans for all Highmast and Floodlighting Systems.
6. Highmast Luminaires photometric requirements shall be as shown on the Standard Drawings, and shall be provided as described in the Standard Specifications. Floodlight luminaire specifications and photometric requirements shall be provided by the Engineer for review and approval by the Authority's Engineering Department. Where proposed equipment is not specified in the Standard Drawings or Specifications, the Engineer shall write supplemental specifications if necessary for specific Highmast and Floodlighting installations to ensure that specific project constraints are adequately addressed.

7.3.4 Emergency Lighting and Generator Backup

Where installed at toll plazas or facilities with emergency generators, all new roadway lighting systems shall be fully connected to circuits that retain power in the case of emergency. Thus, in the event of power failure, all toll plaza lighting shall remain functional.

Lighting systems powered by standalone load centers do not require generator backup, unless otherwise directed.

Many existing toll plazas on the Turnpike have separate Emergency Lighting Systems installed where the entire roadway lighting system is not powered by circuits from the emergency generator. Emergency luminaires, in this case, give illumination on the two approach sides of each Toll Plaza for traffic approaching toll booths in case of power failure.

New Emergency Lighting Systems shall not be installed at either Turnpike or Parkway Toll Plazas. Where projects modify significant portions of toll plaza lighting systems, the Engineer shall consider upgrade of the lighting system for the entire interchange, and connection to the generator. This replacement may also be warranted in order to convert existing series lighting systems to multiple type lighting systems. Should connection of the entire system not be warranted, the Emergency Lighting System shall be maintained, and reinstalled where disturbed.

Emergency lighting luminaires shall be Type-E1 or Type-E2 (see Standard Drawings and Specifications) as necessary to provide sufficient lighting, and shall be installed on top of or on the upper portion of lighting standard shafts, or on top of floodlighting towers, as required. In small toll plazas, a minimum of six emergency luminaires, three on each approach and immediately adjacent to the toll booths, should be provided. However, in large plazas the emergency lighting system should be continuous from each approach bullnose to the toll booths. Details for Emergency luminaire installation shall be requested from the Authority for use in projects that are modifying existing Emergency Lighting systems.

7.3.5 Underbridge Lighting

The intention of underbridge lighting is not to accent the roadways beneath structures, but rather to provide adequate illumination and to achieve continuity of lighting throughout the roadway. Therefore, underbridge lighting shall only be required where, due to structural limitations such as the width, skew and minimum clearance, adequate illumination cannot be accomplished by means of ground-mounted lighting standards.

Underbridge lighting luminaires shall be high pressure sodium type (see Standard Specifications) and shall be installed on bridge piers or abutments (Type-W) or supported by structural members (Type-S), as required.

1. Mounting height shall be as required for proper illumination of the roadway, and as follows:

Type-W Luminaires:	15 ft. minimum
Type-S Luminaires:	Bottom of luminaire in line with bottom of adjacent stringer flange.

2. Luminaire setback (light center to pavement edge distance) shall be as per the following minimum requirements:

Type-W Luminaires:	Face of pier or abutment to pavement edge.
Type-S Luminaires:	3 ft. beyond pavement edge over shoulder.

3. Luminaires wattage of 150 Watt HPS shall be utilized if at all possible. 70 Watt and 100 Watt luminaires will be approved only if necessary to meet Authority design criteria.
4. Photometric requirements shall be as shown on the Standard Drawings and Specifications.
5. For installations requiring Type S luminaires, the Engineer shall ensure that location of the luminaires, and the mounting detail does not block the light output to the roadway. Additional modeling may be required to determine this for installations between tightly spaced stringers.

7.3.6 Toll Plaza Lighting

Toll Plaza Lighting Systems shall conform to the requirements of the other lighting systems described in this Section. The Engineer shall not utilize non-standard lighting systems for toll plazas.

7.3.7 Roadway Tunnel Lighting

Owing to the specialized nature of tunnel lighting, non-standard luminaires and installation methods may be required. The Engineer shall utilize Authority standard luminaires, equipment, mounting, and construction methods wherever possible for tunnel lighting installations. Where it is necessary to utilize non-standard items, the Engineer shall make recommendations of equipment to be installed, and proper installation methods, in accordance with Subsection 7.1.3.

If possible, location of luminaires and mounting shall be as described above for Underbridge Lighting. All conduits and equipment shall be installed to minimize likelihood of vehicle impact, to facilitate relamping and maintenance, and to keep a high level of system uptime.

7.3.8 Maintenance Area / Storage Area Lighting

Storage Facility and Maintenance Yard Lighting shall be constructed of either the Conventional or Pole-Top Cutoff Lighting System. The Engineer shall weigh the various systems and equipment that can be installed, and make recommendations based on engineering judgment.

7.3.9 Parking Lot Lighting

Parking Lot Lighting systems, including the lighting at Service Areas, may require the use of special architectural fixtures and poles. The Engineer shall contact the Authority's Engineering Department for specific design requirements, prior to design.

7.3.10 Temporary Roadway Lighting

Design and construction sequence of the roadway lighting system should be arranged so that the permanent lighting installations will be completed and in operation when the new roadways are opened to traffic. If this cannot be

accomplished, temporary lighting should be provided for these roadways. All installations which are required to be removed at the end of the construction should be of temporary nature.

Illumination levels and uniformity requirements for temporary lighting systems shall be as prescribed above for permanent lighting systems. A temporary lighting system is expected to produce a level of illumination equal to that of a permanent system. However, physical arrangements and equipment criteria are modified to enable an abbreviated and less costly installation. Maintainability, constructability and safety considerations should not be compromised in temporary lighting systems.

The following general criteria are provided for temporary lighting systems. Unless otherwise stated below, criteria relating to permanent lighting systems apply for the design of temporary systems.

1. Screw-type bases or other above-ground bases may be used with lighting standard installations in lieu of concrete bases and Junction Box Foundations where protected from vehicle impact.
2. Wood poles with Type A, B, C or D cutoff cobrahead luminaires with bracket arms or Type P2/P3/P4 HPS luminaires with pole-mounted tenons may be used for roadway lighting applications.
3. Wood poles with HPS offset type luminaires may be used for roadway lighting applications and in areas where a large setback is necessary to clear construction activity. Type-E offset luminaires utilize a modified reflector system to permit use along the edge of roadway while maintaining a standard setback of 3'-6". Offset luminaires are available without the modified reflector system and are designed to perform with a much greater setback. These units, although not a standard type used for Authority systems, are acceptable for temporary installations, where appropriate. Where possible, however, the Engineer shall attempt to use the Type P4 cutoff luminaires to minimize glare in the work area. As with permanent installations, offset luminaires shall be used only where approved in advance by the Authority's Engineering Department.
4. Wood poles with HPS floodlighting type luminaires may be used for area lighting applications.
5. Each temporary lighting standard and wood pole location shall be properly grounded with a separate ground rod installation. Additionally, all temporary distribution wiring (multiconductor direct burial, aerial cable or individual wiring in conduit) shall incorporate a separate ground wire to provide a continuous ground throughout the entire circuit.
6. Lighting standard identification tags, as shown on the Standard Drawings, will not be required for temporary installations. However, an approved weatherproof write-on-type-tag should be installed at each temporary location indicating circuit number and phase connection.

7. Lighting standards and equipment shall be set back from edge of roadway in accordance with the requirements of the Standard Drawings when construction activity will not be expected to conflict or interfere.

7.3.11 Sign Lighting

Sign lighting luminaires, where required, shall be 250 watt mercury vapor with a metal halide ballast as outlined in the Standard Specifications. Illumination, installation, and photometric requirements shall conform to the Standard Drawings. The Contract Plans shall also include the following additional information:

1. Luminaire arrangement for each sign panel, based the tabulation included in Standard Drawing E-xx (to be published at a later date), shall be coordinated with and shown on the Structural Elevations for each illuminated overhead sign structure or bridge-mounted sign.
2. Circuit provisions for each sign structure or bridge-mounted sign, either from roadway lighting circuitry (group controlled) or from a local utility (24-hour service), shall be shown on the Roadway Lighting Plans.
3. Relocation of Sign Lighting where existing sign panels are replaced with new panels, and the new panel is of a different dimension than the old panel.

7.3.12 Navigation and Aviation Obstruction Lighting

The Engineer shall select appropriate Navigation and Aviation Obstruction Lighting equipment per the requirements set forth by the governing authorities (see Subsection 7.2.1.8), and shall utilize this equipment in the design. Fixtures that utilize long-life light-emitting diode (LED) sources shall be favored if available.

7.3.13 Lighting Standard Bases and Junction Box Foundations

Construction methods and typical installation details for standard concrete bases, Junction Box Foundations, junction boxes, and roadway lighting manholes shall be in accordance with Standard Specifications and Standard Drawings. All other special details required for the Project shall be prepared by the Engineer.

While it is recognized that many existing Parkway lighting systems have the Junction Box Foundations oriented with the boxes closer to the road, all newly-installed JBFs shall be oriented with the pole closer to the roadway on all Authority projects.

Junction Box Foundations shall be used wherever possible. Concrete Light Standard Bases with separate Type C or Type D Junction Box shall be used only where specific right of way or project constraints prevent the installation of Junction Box Foundations.

Additional requirements for underground junction boxes, handholes, and manholes may be found in Subsection 7.4.4.1.

7.4 POWER DISTRIBUTION AND RACEWAY SYSTEM DESIGN

7.4.1 General

The Power Distribution System includes all underground and above ground conduits, boxes, manholes, and foundations, wiring, and power distribution equipment necessary to provide the various lighting and other electrical systems with power. All Power Distribution Systems, as well as all raceways shall be designed in accordance with the NEC and the guidance of this Subsection.

7.4.2 Electric Service

7.4.2.1 General

The secondary service obtained from the local utility company shall be used to provide power for the complete installation in each area, except at larger scale installations where it may be more economical to utilize primary service. An economic analysis of each type of service shall be submitted by the Engineer for review and approval by the Authority's Engineering Department.

The Engineer shall coordinate with the utility company on behalf of the Authority to obtain new, modified, and upgraded utility services as project may require. Services shall be located to minimize interference with other project work and as required below in Subsection 7.4.3. The Engineer shall also make every attempt to locate load centers, select voltages and coordinate with the utility company to minimize the extents of Authority maintenance on all new utility services. Coordination shall be as described in Section 7 (Utilities) of the Procedures Manual.

Standard services available from the local utility companies are as follows:

1. 3-phase 4-wire Secondary Service shall be 120/208 Volt or 277/480 Volt. Single-phase 3-wire Secondary Service shall be 120/240 Volt or 240/480 Volt.

Certain older installations on the Turnpike may utilize three-phase 265/460 Volt services. The Engineer shall perform all calculations using the 277/480 Voltage, but shall note the 265/460 Volt installation methods in the plans accordingly.

2. Primary Service: 2,400/4,160 Volt and 7,620/13,200 Volt

4,160 Volt service should be used, except in those restricted areas where only 13,200 Volt may be available. This matter should be checked with the utility company.

7.4.2.2 Building Electrical Services

At building locations, if secondary service is used, additional transformation shall be made by means of a bank of single-phase transformers (preferred) or a three-phase transformer in the building, in order to provide two (2) types of utilized voltages for the building and roadway lighting service requirements. If primary service is used, an outdoor transformer station within the immediate vicinity of the building shall be constructed to service the entire area. Two (2) sets of single-phase, oil-immersed transformer banks shall be installed in the transformer station to accommodate the utility building and roadway lighting service requirements.

In addition, each Utility Building shall be provided with an emergency generator of the required size, to include all roadway lighting load in addition to building emergency loads.

New lighting distribution panels and load centers shall be located within buildings, and not in free-standing outdoor enclosures, unless required for installation due to space constraints or maintenance (i.e. for series-type transformer stations). This requirement includes toll plaza utility buildings.

7.4.2.3 Services Not Located at Buildings

In areas where the existing roadway lighting and associated facilities are being modified and/or expanded, the existing load centers are generally located in the interchange Utility Buildings or outdoor transformer stations. Circuitry originating at these existing load centers shall be used for the modified and/or expanded lighting facilities, to the maximum extent possible.

Where lighting loads and the physical limits of circuitry prohibit the utilization of existing load centers, new outdoor type load centers shall be provided as described in Subsection 7.4.3.

Transformation for standalone load centers shall be by utility transformer, either pad-mounted near the load center, or mounted on the pole nearest the load center installation. Load center voltage may be determined by the available voltages on the utility power distribution system located near the load center.

7.4.2.4 Utilized Voltage

Utilized voltage for various Power Distribution facilities shall be as follows:

1. Buildings: 120/208 Volt 3-phase, 4-wire (Building lighting and equipment)
277/480 Volt 3-phase, 4-wire (HVAC and certain lighting loads - see below)
2. Roadway Lighting: 277/480 Volt, 3-phase, 4-wire
120/240 Volt, single-phase, 3-wire
240/480 Volt, single-phase, 3-wire (Engineer to determine supply voltage on Parkway. 277/480 Volt to be supplied at all Turnpike locations and where possible on the Parkway.)
3. Highmast Lighting: 277/480 Volt, 3-phase, 4-wire.
4. Floodlighting: 277/480 Volt, 3-phase, 4-wire.
5. Underbridge Lighting: To be connected to roadway lighting circuits, where available. Engineer to determine voltage for standalone installations.
6. Emergency Lighting: 120/208 Volt, 3-phase, 4-wire.
277/480 Volt, 3-phase, 4-wire, as required. (existing installations only)
7. Overhead Sign Structures with Fixed Message Signs: To be connected to roadway lighting circuits, where available.
8. Changeable Message Signs: Power and control 120/240V, single phase, 3-wire (24-hour service). Lighting shall be connected to roadway lighting circuits where available, otherwise serviced from the 24-hour power and control circuits.
9. Emergency Speed Warning/ Speed Limit Signs: 120/240V, single phase, 3-wire (24-hour service) for all power, control and lighting.
10. Variable Message Signs: 120/240V, single phase, 3-wire (24-hour service) for all power, control and lighting.

11. Other Roadway and ITS Devices: 120/240 Volt, single-phase, 3-wire, or connected to area 24-hour power circuits

Power for facilities which require normal and emergency service shall be obtained from the Utility Building lighting panels. The entire roadway lighting system, including highmast and floodlighting, shall be fed from the roadway lighting panelboard.

The 24-hour service for changeable message signs, emergency speed warning/speed limit signs, variable message signs, cameras, and other ITS devices shall either be obtained from the roadway lighting panelboards at 480 Volt (2-wire) and transformed to 120/240V in the load center at the sign location or obtained from a local utility service pole, as required.

At certain long-span bridges and southern toll plazas on the Turnpike, existing series lighting systems are still in use. Where a substantial portion of the lighting system requires replacement as a result of project work and a multiple system is feasible, the system shall be upgraded to a multiple system at the utilized voltages listed above. In this case, the lighting distribution equipment / load center shall be replaced. Conversion work from a series to a multiple system shall require, at a minimum, replacement of system wiring and luminaires. The Engineer shall perform an analysis of the cost of this work, to be included with the Phase "A" submission, in order for the Authority's Engineering Department to review and approve the system replacement.

Where existing series systems are not replaced as a result of project work, the Engineer shall perform all calculations and design using industry standard practices for series system lighting design.

7.4.3 Circuitry and Voltage Drop

1. Minimum size of cable for roadway lighting circuits shall be #2 AWG, and maximum shall be #4/0 AWG. Other standard sizes, such as #1/0 AWG, and #2/0 AWG shall be used as required, but it is recommended that variations in cable sizes be kept to a minimum in each project. Parallel feeders shall not be installed for lighting systems. Where ampacity allows, #6 AWG wiring is permitted to be installed between the main lighting feeder and various equipment, such as sign lighting, variable message signs, or various other ITS devices. #10 AWG wire between feeders and individual fixtures or equipment shall be permitted to be installed up to a length of fifty (50) feet.
2. On the Turnpike and where possible on the Parkway, the Power Distribution system for roadway lighting and other roadway equipment shall be fed from a single load center installation, which is generally to

be located inside an Authority-owned building (Utility, Toll Plaza, Police Barracks, Service Area, Maintenance Shop, etc.).

In very large areas, additional (auxiliary) standalone load center installations may prove to be more economical than running extremely long circuits requiring large size cables. Service for these installations may be extended from main building if primary service is used; otherwise secondary service should be obtained locally from the utility. Pad-mounted transformers should be used in conjunction with auxiliary load centers which are provided with primary service.

Where smaller projects require installation or modification of Roadway Electrical Systems and power is not available from a nearby building, a standalone load center shall be installed, and secondary service obtained from the utility locally. Effort shall be taken to minimize the number of standalone load centers, and therefore ongoing maintenance and cost.

Engineers shall prepare a cost-benefit analysis when proposing more than one standalone load center in a given project, to be submitted for review at the time of the Phase "A" Submission.

Standalone load centers shall be installed as shown in the Standard Drawings, and as described below under Utility Services.

3. All lighting systems shall be group controlled by means of a photoelectric control device dedicated for use by the system. The photoelectric control shall be located where it is easily maintained and facing North where possible for optimal operation. The photoelectric control shall be wired to control a single contactor that feeds a separate roadway lighting panelboard. Individual circuits shall not be controlled by the photocell. The photocell shall be located such that it is not affected by light sources in the vicinity of the lighting control equipment, to ensure continuous reliable nighttime operation of the lighting system.
4. Where 24-hour continuous-on circuits are required for equipment that is in an area served by a Roadway Lighting System, the 24-hour circuits shall be powered from the same utility room or load center, and the power shall be taken from a circuit located "upstream" of the Roadway Lighting contactor.
5. For three-phase systems, each circuit shall be 3-phase, 4-wire with a shared neutral. Luminaires shall be connected to alternate phases of the same circuit. For single-phase systems, each circuit shall be 2-leg, 3-wire with a shared neutral. Luminaires shall be connected to alternate legs of the same circuit. Ballast connections shall be made between the phase and neutral cables of each circuit in order to accommodate the appropriate voltage operation. Phase-to-Phase installations shall be avoided, and shall be utilized only where approved in advance by the Authority's Engineering Department.

6. For three-phase, 4-wire and single-phase 3-wire phase-to-neutral circuits, all phases and legs of each circuit shall be balanced as closely as possible to minimize the neutral current.
7. Each luminaire ballast shall be individually protected by means of a fused cable connector kit, as indicated on the Standard Drawings.
8. For both single- and three-phase circuits, the lighting circuits shall be designed for a maximum current of 35 Amps, and shall be provided with a circuit breaker with maximum 50 Amp trip capacity at the panelboard. For circuits where 35 Amp capacity is insufficient, the maximum current may be increased to 50 Amps, and the circuit breaker trip increased to 70 Amps. Breaker trip currents shall be selected to be at least 140% of continuous circuit current, to allow operation of the lighting loads and prevent nuisance tripping. Lower circuit breaker sizes shall be allowed, and are preferred in smaller installations to reduce wire size. The Authority maintains no set limit of the number of luminaires that may be connected to a given circuit, as long as each circuit meets the other requirements of this Section.
9. Continuous-on 24-hour circuits shall be designed to utilize a maximum breaker size of 20 Amps, unless otherwise noted or the specific equipment to be powered requires a larger circuit ampacity.
10. Lighting circuits shall be designed for a maximum of 3% voltage drop at the terminal point of each circuit (including the future lighting extensions, where required) calculated between the phase and neutral. All circuit breakers for area lighting circuits in the panelboard shall be of the single pole type.

Final voltage drop calculations shall be based on actual current on each phase and unbalance current in the neutral for each circuit length between all lighting equipment and other loads, etc., utilizing AC resistance for uncoated copper conductor as listed in NEC Chapter 9 (Table 9). To simplify calculations, up to fifty (50) feet of #10 AWG fixture wire between the feeder and luminaires shall be permitted to be omitted from the voltage drop calculations.

All single-phase and three-phase systems shall be analyzed using a single-phase method utilizing the Authority's *Standard Voltage Drop Computation Form*. An electronic version of the Excel Spreadsheet is available on the Authority's website. Each leg/phase of the circuit shall be analyzed separately. A sample completed form and sketch are shown following in Exhibit 7 - 22.

Voltage drop calculations shall take into account all existing equipment to remain in place for the final design. It shall not be sufficient to analyze to voltage drop for new equipment only, unless the entire circuit is new.

EXHIBIT 7 - 22
SAMPLE VOLTAGE DROP CALCULATION FORMS 1 AND 2

New Jersey Turnpike Authority
Standard Voltage Drop Computation Form 1 - Calculations

XYZ Engineering Company 100 Main Street Hackensack, NJ 07601		Made by	Date	CIRCUIT # 3
		M. Nesmith	1/2/2003	PHASE # B
		Checked by	Date	VOLTAGE # 277 V
Contract No:	T300.019	D. Jones	1/3/2003	
Name:	Interchange 19 Reconstruction	Backchecked by	Date	Sheet Number
		P. Tork	1/5/2003	1 of 2

Instructions:

Calculations shall be performed for each circuit branch separately, including all existing lamps and loads, if any are connected to the circuit. Select worst case branch voltage drop to determine total circuit voltage drop. DO NOT TOTAL ALL DROPS. Use NEC Chapter 9, Table 9 to determine appropriate resistance values, taking into account overall circuit Power Factor as described in the footnotes to the Table. Use additional forms if required for long circuits. Complete one complete set of forms for each circuit and phase.

Section	From	To	Current	Distance	Ohms/K ft	Z=2xLx0.001xΩ	Vd=IxZ
			I	L	Ω	Z	Vd
BRANCH A							
1	Panel	JB1	8.77	500	0.2	0.20	1.754
2	JB1	1-3-B	3.51	700	0.2	0.28	0.983
3	1-3-B	4-3-B	2.34	250	0.2	0.10	0.234
4	4-3-B	7-3-B	1.17	250	0.2	0.10	0.117
						TOTAL	3.088
BRANCH B							
1	Panel	JB1	8.77	500	0.2	0.20	1.754
2	JB1	10-3-B	5.26	400	0.2	0.16	0.842
3	10-3-B	JB2	4.09	300	0.2	0.12	0.491
4	JB2	13-3-B	2.34	300	0.2	0.12	0.281
5	13-3-B	16-3-B	1.17	200	0.2	0.08	0.094
						TOTAL	3.461
BRANCH C							
1	Panel	JB1	8.77	500	0.2	0.20	1.754
2	JB1	10-3-B	5.26	400	0.2	0.16	0.842
3	10-3-B	JB2	4.09	300	0.2	0.12	0.491
4	JB2	19-3-B	1.75	100	0.2	0.04	0.070
						TOTAL	3.156

Worst Case Branch: B

% Vd = 3.461 V / 277 V = 1.25% is less than 3%

Comments: (To be filled in by Engineer)

All wires selected to be #2 AWG in steel conduit (Z=0.20 Ω per 1000 ft - per NEC Chapter 9, Table 9), Power Factor assumed to be 0.96.

New Jersey Turnpike Authority
Standard Voltage Drop Computation Form 2 - Sketch and Details

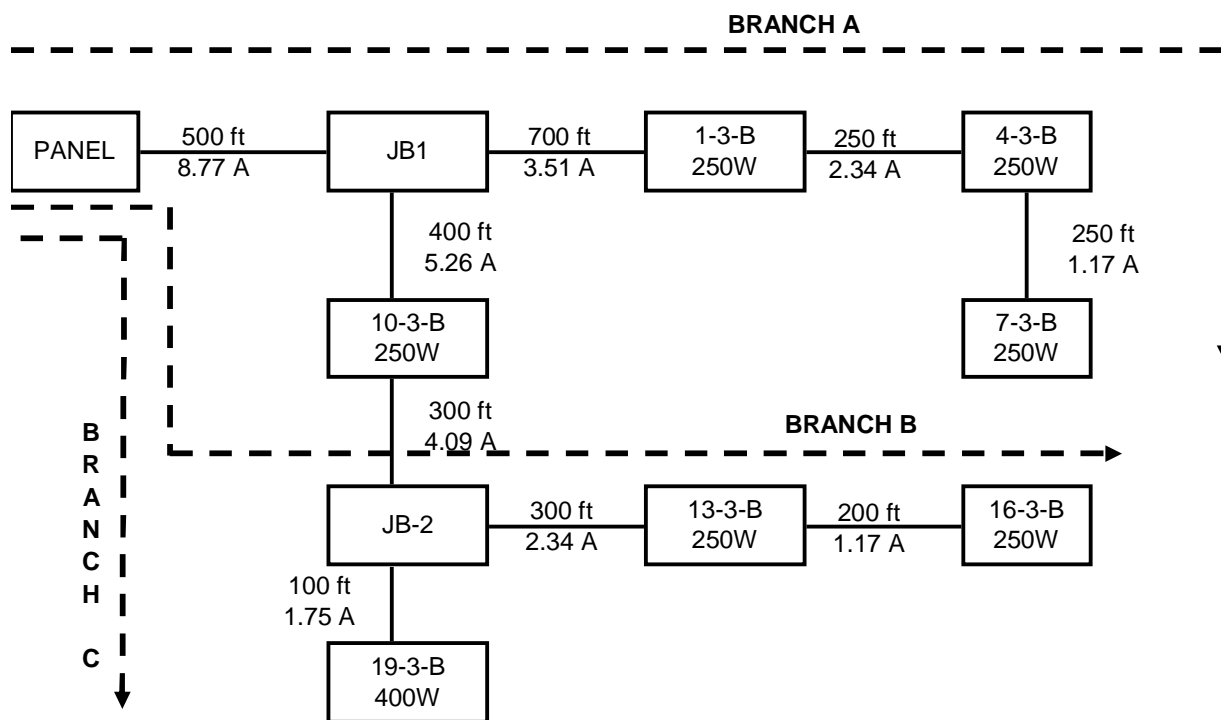
XYZ Engineering Company 100 Main Street Hackensack, NJ 07601		Made by M. Nesmith	Date 1/2/2003	CIRCUIT # 3
		Checked by D. Jones	Date 1/3/2003	PHASE # B
Contract No:	T300.019	Backchecked by P. Tork	Date 1/5/2003	VOLTAGE # 277 V
Name:	Interchange 19 Reconstruction			Sheet Number 2 of 2

Circuit Information

Load Center Location	Plaza Utility Building	Voltage:	277 V																				
Total Load (kW):	1.9 kW	Phase and # Wires	Three Phase, 4-Wire																				
Wire Size:	#2 AWG	Conduit Type:	RMC Steel																				
Lamp Quantities:	<table border="1"> <thead> <tr> <th>Watts</th> <th>Quantity</th> <th>Watts</th> <th>Quantity</th> </tr> </thead> <tbody> <tr> <td>70</td> <td></td> <td>250</td> <td>6</td> </tr> <tr> <td>100</td> <td></td> <td>310</td> <td></td> </tr> <tr> <td>150</td> <td></td> <td>400</td> <td>1</td> </tr> <tr> <td>200</td> <td></td> <td>1000</td> <td></td> </tr> </tbody> </table>	Watts	Quantity	Watts	Quantity	70		250	6	100		310		150		400	1	200		1000			
Watts	Quantity	Watts	Quantity																				
70		250	6																				
100		310																					
150		400	1																				
200		1000																					

Instructions:

Show a sketch of the circuit below. Do not include any #10 AWG fixture wire.

**Comments: (To be filled in by Engineer)**

All wire for this circuit is #2 AWG

11. Lighting circuits shall be so arranged that in case of failure in one of the circuits, it is possible to re-route the failed circuit with a minimum of work. In order to accomplish this flexibility in the circuitry, an empty conduit shall be provided to connect the adjacent circuits, where feasible, and all four (4) cables of each circuit shall be extended to the respective junction box, Junction Box Foundation or manhole at each end of such empty conduit. Terminals of the unused cables shall be test capped in each junction box or manhole.
12. Spare conductors shall be installed if future roadway devices or lighting is anticipated. All feeder phase conductors shall be continued to the last device on each circuit, and unused conductors shall be shown as capped in the junction box or manhole. This procedure ensures that future continuation of circuits, or future changing of phase connections is possible.
13. In all toll plazas or roadways where additional future widening is contemplated, the locations of underground conduits, junction boxes, manholes and floodlighting towers should be beyond the limits of future widening, if possible. Lighting standards, however, should be installed along the present edge of the pavement.
14. Where multiple circuit feeders are installed in one conduit, the conductor ampacities shall be derated in accordance with the NEC.
15. Lamp ballast input wattages shall be as shown in the following Exhibit 7 - 23:

EXHIBIT 7 - 23
TABLE OF BALLAST INPUT WATTAGE / CURRENT

Lamp Output (Watts)	Total Input (Watts)	Amperes at 120 Volts	Amperes at 208 Volts	Amperes at 240 Volts	Amperes at 277 Volts
70 HPS	100	0.87	0.50	0.43	0.38
100 HPS	140	1.22	0.70	0.61	0.53
150 HPS	190	1.65	0.95	0.82	0.71
200 HPS	250	2.17	1.25	1.09	0.94
250 HPS	310	2.69	1.55	1.35	1.17
310 HPS	365	3.17	1.83	1.58	1.37
400 HPS	465	4.04	2.33	2.02	1.75
1000 HPS	1100	9.55	5.51	4.77	4.14
250 MV	290	2.52	1.45	1.26	1.09
NOTES:	Values shown only for lamps typically used on Authority projects. Ampere values shown assume a lagging power factor PF = 0.96, which shall be used to calculate current for lamps of other types. For lamps of other types, the Engineer shall determine Watt, Ampere, and Power Factor values using the fixture manufacturer's recommendations.				

The Engineer may use different values from those shown above if engineering judgment dictates that actual wattages will differ from the values shown in the above table.

7.4.4 Raceway System Design

7.4.4.1 Underground Junction Boxes, Handholes, and Manholes

1. In order to facilitate cable pulling and splicing, a junction box or manhole, as required, shall be installed adjacent to each lighting standard base, highmast or floodlighting tower, illuminated sign structure pedestal, bridge-mounted sign, underbridge lighting system, and at each end of conduit crossings under roadways. The location of conduit crossings shall be so arranged that the junction boxes or manholes at such crossings can also be used as service points to the above-noted facilities.
2. The junction box may be omitted at a lighting standard located at the end of a circuit where no future expansion is anticipated.
3. Junction boxes shall be installed at the end of spare conduit runs in barriers, walls, and structures, at the point nearest the wingwall, for future continuation of the conduit.
4. Junction boxes and Junction Box Foundations shall be installed within a maximum pulling distance of 250 feet.
5. Standard junction boxes are designed to carry a maximum of three (3) in-line conduits. Manholes should be used in lieu of

junction boxes whenever there are more than three (3) in-line conduit runs, or where angled pulls require a larger box (as dictated by the requirements of the NEC).

6. In special cases where the number of circuits and cable sizes involved are in excess of the standard manhole capacity, larger manholes of an approved design should be used. Large size manholes may be of cast-in-place type, and the Engineer shall provide a design in the plans.
7. Type D Junction Boxes shall be used in all barriers and parapets as shown in the Standard Drawings. Alternate designs will not be accepted.

7.4.4.2 Conduits and Raceways

1. Separate conduit raceways shall be provided for each roadway lighting circuit. In certain cases where small size wiring is required, cables for two or more circuits may be installed in the same conduit.
2. Wherever practical, wiring for 24-hour circuits shall be contained in a conduit dedicated to this use. However, 24-hour circuits shall be permitted to pass through junction boxes for Roadway Lighting or other systems, provided the insulation on all cables is sufficient for the maximum voltage present in the box.
3. At all locations where conduits pass under an active roadway, driveway, or parking area, a spare conduit shall be provided in addition to all conduits required for the initial system installation. At major main feeder crossings, two spare conduits are recommended. One spare conduit, in addition to the active conduit, should be provided on all bridge and wall structures, even those structures which do not require installation of wiring or cables at the time the structures are constructed.
4. ***Conduits shall be provided in barriers, walls, and bridge parapets as outlined in this subsection. Conduits shall be placed in accordance with details shown on Authority Standard Drawings BR-4 and BR-7. More specifically:***

Bridges carrying mainline or ramp roadways

- ***Bridge parapets adjacent to the right shoulder(s) on structures carrying mainline roadways shall be provided with two 3" diameter (nom.) conduits.***
- ***One bridge parapet on structures carrying entry/exit ramp roadways shall be provided with two 3" diameter (nom.) conduits. The conduits shall be located in the parapet which supports the ramp roadway lighting, if***

applicable. There is no preference as to which parapet the conduit shall be located in for these structures which do not have roadway lighting.

- *These conduits shall only be used to support circuits that power lighting and/or electrical appurtenances located directly on that bridge as required by current or future design. Conduits designated for future use which are not connected past the end of a structure shall be terminated and capped in the embankment a minimum of 10 feet past the end of the wingwall and/or approach slab.*
- *A single 3" diameter (nom.) conduit shall be installed in one of the two bridge parapets on dedicated "Official Use Only" U-turn structures. It is preferred that the conduit be located in the parapet adjacent to the inside radius of these structures which are configured into a "U" type alignment. There is no preference as to which parapet the conduit shall be located in for these structures which are configured into an "S" type alignment.*
- *Conduits designated for future use which are not connected past the end of a structure shall be terminated and capped in the embankment a minimum of 10ft past the end of the wingwall and/or approach slab.*

Retaining Walls

- *Retaining walls that are continuous with bridges carrying mainline and/or ramp roadways shall be provided with conduits in parapet(s) to match the conduits in the adjacent bridge parapet(s). These conduits shall be continuous with the conduits in the adjacent structure parapet(s). Free standing retaining wall parapets that are not continuous with bridges carrying turnpike mainline and/or ramp roadways and supporting roadways that do not require lighting or ITS facilities shall not be provided with conduits. Conduits located along retaining wall alignments shall be placed in the embankment under the roadway shoulder pavement only where required by design for roadway lighting or ITS systems.*
- *Conduits designated for future use which are not connected past the end of a retaining wall structure shall be terminated and capped in the embankment a minimum of 10 feet past the end of the retaining wall.*

5. ***All local road structures over Turnpike and Parkway roadways shall have provisions for two (2) 3" conduits, to be located in either parapet. The conduit is to be a provision for future lighting or utility work. More specifically:***

Bridges not carrying mainline or ramp roadways

- ***One of the bridge parapets on structures carrying local roadways over mainline or ramp roadways shall be provided with two 3" diameter (nom.) conduits. The conduits shall be located in the parapet which supports the local roadway lighting, if applicable. For two-direction bridges, there is no preference as to which parapet the conduit shall be located in for structures which do not have roadway lighting. For one-direction bridges, preference shall be given to the parapet adjacent to the larger roadway shoulder or sidewalk. Additional conduits may be required as per local road owner criteria, and as approved by the NJTA. The provisions of Bullet 3 under Bridges carrying mainline or ramp roadways above do not apply for local road bridges. Additional conduits which are required for these structures by local road owners shall be located in the structure parapet, if practical.***
6. All local road structures over Turnpike and Parkway roadways shall have provisions for two (2) 3" conduits, to be located in either parapet. The conduit is to be a provision for future lighting or utility work. The Authority's Engineering Department should be contacted for updated information on this matter.
7. Underground handholes, manholes, junction boxes, and other structures carrying electrical wiring shall be drained by connecting a 2" minimum perforated PVC pipe to the nearest drainage inlet. Care shall be taken to ensure that the inlet invert is below the bottom of the box or manhole to prevent water from flowing through the electrical raceway system. A removable screen or filter fabric shall be installed to prevent sediment from entering the drain pipe. Pipe installation shall be shown on the drainage plans, and shall be noted on the Electrical and/or Roadway Lighting Plans. Where electrical equipment is installed in areas without drainage systems, the Engineer shall assess whether supplementary drainage is required for the electrical installation, taking into account the height of the water table, soil material, etc.
8. Unless installed in an environmentally controlled space with no likelihood of water entering the conduit system, conduits shall enter all exposed cabinets from the bottom, or on the sides within 2" of the bottom of the cabinet. Under no circumstances shall

conduits be allowed to enter the tops of any exterior, or tunnel-mounted cabinets containing electrical equipment.

9. Wireways shall be used in installations wherever practical to minimize the number of conduits necessary. Where communications and power raceways are required to connect multiple equipment enclosures, a partitioned wireway shall be permitted. The partition shall be mechanically attached to the wireway such that its water-tightness is not compromised.
10. The entire raceway system shall be grounded and bonded in accordance with the NEC. A separate ground wire shall be installed in all raceways such that the resistance to ground, and therefore the fault current path, is not dependent on such mechanical connections as couplings and fittings.
11. Concrete-encased duct banks shall be installed as shown on Standard Drawing E-xx (to be published at a later date) where more than 3 conduits are installed in one trench under a paved surface. Additionally, concrete-encasement should be considered as an option by the Engineer for high-importance, low-downtime raceway facilities where they might be easily interrupted by construction or other normal operations, or where minimum cover requirements cannot be met due to conflicts with other utilities or sub-surface structures. Where duct banks are installed, at least 50% spare conduits shall be provided, in accordance with the other requirements of this manual.
12. The Engineer shall perform conduit fill calculations for each raceway, ensuring that no conduits are overfilled as per the requirements of the NEC. Actual cable diameters shall be used in these calculations. Where there is a likelihood of future additional wiring to be installed in any conduit, spare capacity shall be maintained in the conduit. While not required for plan review as part of the Phased Submissions, conduit fill calculations shall be submitted for review if requested by the Authority's Engineering Department.
13. Ducts are to be provided at all Turnpike and Parkway structures for the future installation of future communications cables unless otherwise directed. The Engineer shall contact the Authority's Engineering Department for the current appropriate number and location of the conduits. Underground conduits are also to be provided from each abutment backwall to an appropriate location. Typical treatments used can be seen on Exhibits 7 - 24 and 7 - 25. These treatments must be verified as current or modified appropriately.

EXHIBIT 7 - 24 **INSTALLATION OF COMMUNICATIONS CONDUIT ON AUTHORITY BRIDGES**

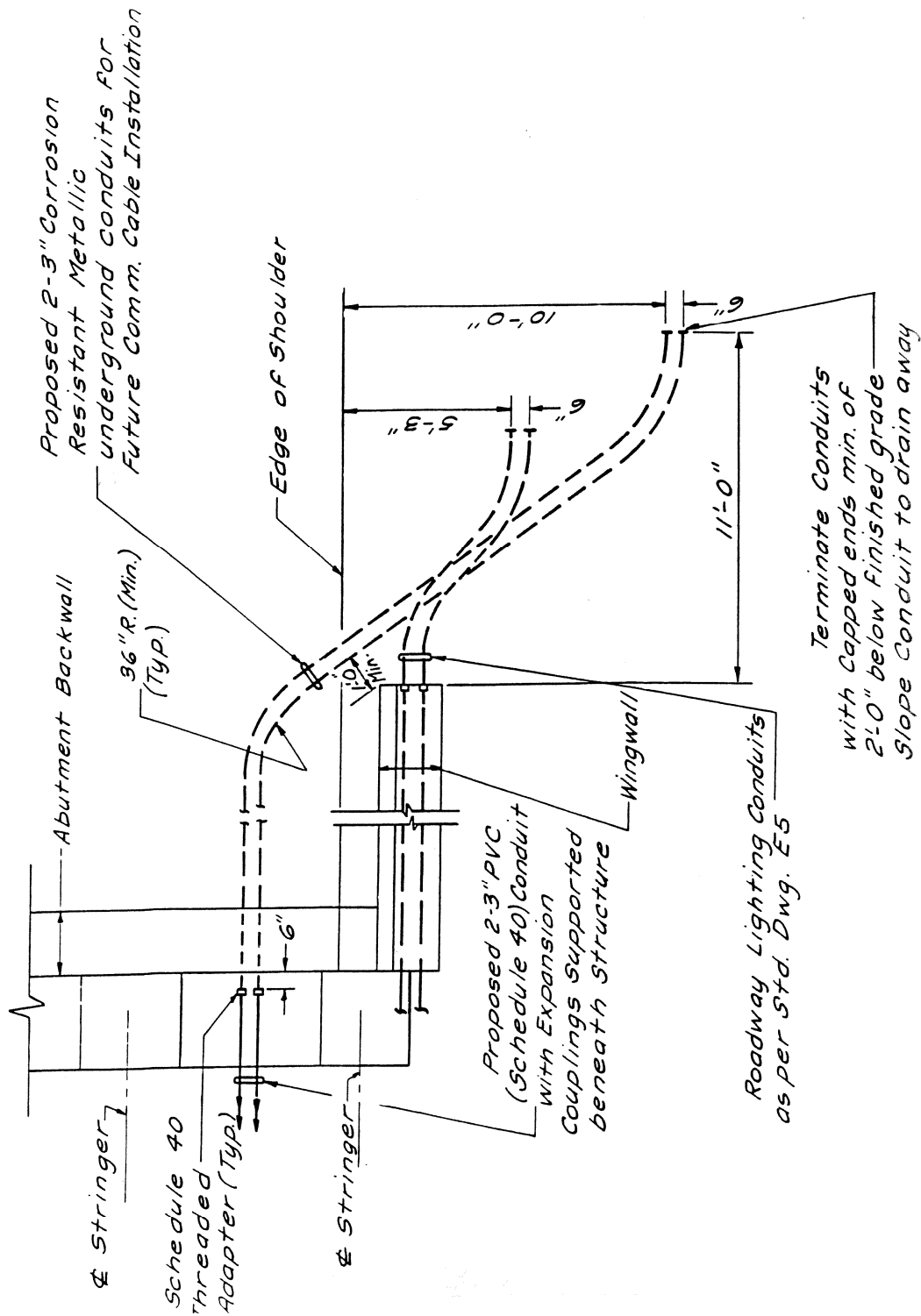
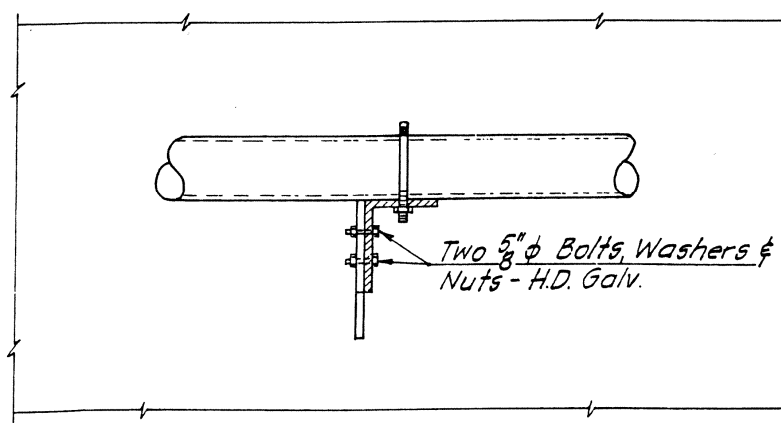
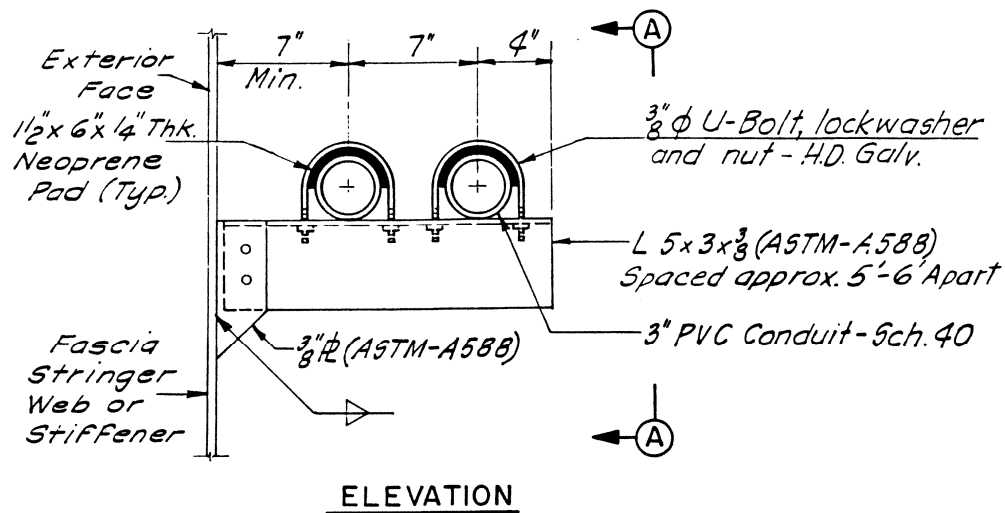


EXHIBIT 7 - 25
COMMUNICATIONS CONDUIT INSTALLATION DETAILS



TYPICAL
COMMUNICATION CONDUIT INSTALLATION DETAILS

14. To prevent vehicle impact, where conduits are provided running under bridge structures and/or attached to stringers, no part of the conduits or attachment method shall protrude under the lowest point of any stringer.
15. Where raceways are installed for bridge-mounted applications, no welding will be permitted to structural steel members. Where possible, all conduits and raceways shall be mounted by clamped

or other non-invasive installation. All drilling and modification to existing and proposed steel or concrete structures necessary to mount raceway systems shall be approved by a Structural Engineer.

7.4.5 Temporary Power Distribution Systems

Where possible, new power distribution systems shall be designed to minimize the need for temporary facilities during construction. However, where temporary power distribution systems are required, either to facilitate construction activities or to power roadway or other electrical equipment during construction, the following requirements shall be taken into consideration, in addition to the requirements listed above for permanent installations:

1. Multi-conductor cable rated for 600V and suitable for direct burial use shall be permitted for underground installations between temporary lighting standard and wood pole locations. Wiring may be installed in rigid metallic or non-metallic conduit, as appropriate when deemed necessary due to the staging or methods of construction employed in the vicinity of temporary underground wiring.
2. Overhead wiring installations, including self-supporting aerial messenger cables, will be permitted for use with temporary roadway and area lighting systems on a case-by-case basis with prior approval by the Authority's Engineering Department. The Engineer shall certify that said overhead wiring system will not interfere with the contractor's construction operations, especially those requiring heavy equipment.
3. Temporary wiring systems provided on bridges or other structures shall be installed in rigid metallic or non-metallic conduit, as appropriate and properly supported or attached to the structure by means of approved conduit support hangers, clamps and hardware. Self-supporting open air wiring installations will not be permitted.
4. All wiring installed in conduits underground or on structures should be maintainable and conduit systems shall incorporate a means of pulling cable at maximum 250 ft. intervals. This may be accomplished by using various devices which may include temporary junction boxes, handholes, lighting standard transformer bases, conduit pulling fittings, or other re-enterable equipment. Access to pulling points should be unrestricted.
5. All wiring splices shall be in junction boxes, handholes, etc. and shall be made using wiring connector kits as shown on Electrical Standard Drawings.
6. Temporary distribution circuitry shall be designed to maintain a maximum voltage drop of 3% between line and neutral conductors. Existing multiple-wire circuits should be utilized wherever possible, however, a careful analysis shall be performed to determine the influence of

temporary facilities connected to existing circuitry. All multi-phase circuits shall be properly balanced. In the event existing circuitry will not support additional temporary loads, a temporary load center with separate utility service may be utilized. An analysis of additional loading on existing circuits, and the possible need for temporary load centers shall be included in the Phase "A" Submittal package.

7.5 POWER DISTRIBUTION AND RACEWAY SYSTEMS EQUIPMENT AND MATERIAL

7.5.1 Conduits, Cabinets, Wireways and Fittings

The Various types of conduits to be used shall be as specified in the Standard Specifications, shown on the Standard Drawings and further prescribed hereinafter.

1. In general, nonmetallic PVC Schedule 80 conduit shall be used for installations under paved roadways, ramps, and parking areas. PVC Schedule 40 conduit shall be used in all areas where vehicular traffic is not expected.
2. Conduits on concrete, steel, or other exterior structures, and in any environment that is not environmentally controlled shall be galvanized rigid steel (RMC). All attachment hardware shall be stainless steel or cast malleable iron. In order to minimize corrosion where conduits transition from an underground distribution system to a structure that is exposed to the air, a short section of PVC-coated galvanized rigid steel conduit shall be installed from a location 3 feet above grade to at least 2 feet below grade. This PVC-coated RMC shall then be permitted to be coupled to a PVC conduit to continue its run to the nearest underground junction box or manhole. A continuous ground wire shall be provided in all metal conduits.
3. Conduits on aluminum structures shall be fabricated of aluminum, and shall be mounted using stainless steel hardware.
4. PVC-coated galvanized rigid steel conduit and hardware shall be used on all structures that are exposed to corrosive areas, especially on bridge structures over bodies of saltwater. PVC-coated conduit shall also be used in all damp locations, and where conduits are cast in concrete, for the portion of the conduit run that makes the transition from the concrete to the open air. A detail shall be provided for all such installations in the plans.
5. Fiberglass reinforced (FRE) conduits shall be permitted to be installed under bridge structures and for cast-in-concrete installations. Adequate supplemental grounding shall be provided in all installations.
6. Rigid metallic conduit shall not be used underground except as noted above.

7. PVC Schedule 40 or 80 shall not be used in any exposed installation, and shall not be permitted to be exposed to sunlight.
8. Electrical metallic tubing (EMT) shall be used only in environmentally-controlled, finished portions of buildings. EMT shall not be installed in any areas that are damp or that may be exposed to water.
9. Flexible metallic conduit shall be installed in maximum six (6) foot lengths where required to make complex bends, or where required to allow for flexibility in movement. Expansion/compression fittings shall be used instead of flexible conduit wherever the degree of expansion is within the allowable tolerances of these fittings.
10. Flexible metallic conduit shall not be used where rigid metallic conduit can be installed.
11. All conduits for roadway lighting distribution circuits, unless otherwise indicated on the Standard Drawings and/or prescribed herein, shall be three-inch (3") size. Two-inch (2") conduit may be used for lighting standards at the end of a circuit where no future expansion is anticipated and approved by the Authority's Engineering Department. Duct banks at toll plazas or other Authority facilities for installation of multiple power and communication cables shall be minimum four-inch (4") size.
12. Cable duct will not be permitted for use in any Roadway Electrical installations. Certain typical details regarding conduit installations are included in the Standard Drawings, and shall be utilized wherever possible on each project.
13. Fittings used shall be of the same material as the conduit they are attached to.
14. Wireways and cabinets shall be constructed of stainless steel, and provided with a NEMA 3R or 4X rating. Details of mounting shall be included that show mounting without compromising the water-tightness of the wireway. Where it is likely that water could collect in the wireway or enclosure, a drain hole shall be provided in a location that will not allow water entry.
15. Conduit shall not be shown entering the top of any cabinet or wireway. See Subsection 7.4.4.2.
16. Unless otherwise approved, minimum size of conduit underground shall be 2" and minimum size of all other conduits shall conform to the Standard Specifications.
17. Compression fittings shall not be allowed, except in buildings for EMT installations, where permitted as described above.

18. Conduits shall be shown running either parallel or perpendicular to key structural elements, and shall be installed with at least 1" clear between the conduit and structure to allow for drainage and to prevent debris accumulation.
19. Conduits for underbridge and other structure lighting systems shall be surface mounted unless shown otherwise in the Standard Details or Specifications.
20. All cabinets and equipment mounted on sign structure pedestals, bridge abutments, or in other installations near active roadway shall be mounted to prevent snow accumulation during and allow access during plowing operations. In most cases, this requirement can be met by placing all equipment on the backside or "downstream" side of the structure.

7.5.2 Cables and Wires

1. All multiple lighting, power, series lighting, and primary and secondary cables, including neutrals, shall be single conductor, stranded copper, and shall be of the voltage ratings, types and with continuous factory-applied color-coding as specified in the Standard Specifications.
2. Ground wire to be used in conjunction with roadway electrical and associated circuits shall be bare, stranded and tinned/coated copper, as specified in the Standard Specifications and/or Standard Drawings. Ground wire to be used in circuits within building and between panels shall be insulated and continuously colored green.
3. All splices, including in-line connections, for roadway lighting cables shall be made by means of fused or non-fused cable connector kits as shown and specified in Standard Electrical Drawings.
4. Cables and wiring required for Communications Systems, where not included in the Standard Specifications or Standard Drawings, shall be indicated on the plans. All cables to be utilized in outdoor installations, whether above or underground, shall be rated to be chemical-proof, oil-proof, UV-resistant, and capable of being continuously submersed in water.
5. Cables to be installed in confined spaces or roadway tunnels shall be low-smoke zero-halogen type.
6. SOW or SOOW type multi-conductor cable shall be installed for all navigation lighting installed on piers instead of fixed conduit system.
7. Installations requiring high degree of cable flexibility, including cables that are required to move for equipment operation, shall utilize cables specifically designed for that purpose.

8. A complete specification for all non-standard cables, including relevant industry testing standards and material certifications, shall be clearly indicated on the Plans for ease of future replacement. The Supplementary Specification shall be utilized only for additional / supplemental material and payment information.
9. A requirement shall be added to all contract drawings stating that a nylon pull cord shall be installed with all wiring and in all empty conduits to facilitate the future installation of additional wiring.

7.5.3 Standalone Load Centers

The load center installation shall consist of the roadway lighting panelboard, remote control switch, contactors, relays, photoelectric bypass switch, control switches, etc. All this equipment shall be furnished without enclosures and installed in a free-standing cabinet according to the details on the Standard Drawings (to be issued at a later date). The bottom of the cabinet shall be used as the wiring section.

Standalone load centers for standard voltages and loads shall be installed in accordance with the Standard Drawings (to be published at a later date). The larger Type F three-phase load center shall be used for 1) large-scale 277/480 Volt lighting distribution systems on the Turnpike, 2) on the Parkway where lighting load exceeds 30 kW, or 3) other project considerations require additional power or equipment space. The smaller Type G single-phase load center shall be used for smaller 120/240 Volt and 240/280 Volt single-phase, and 120/208 Volt three-phase installations on the Parkway where total continuous load served does not exceed 30 kW.

7.6 DESIGN SUBMISSION REQUIREMENTS

The format for plan submission for roadway lighting shall conform to applicable requirements of Section 3 (Submission Requirements) of the Procedures Manual, and as described in Subsection 7.7.

Following is a description of the requirements for the various plan submissions for Roadway Lighting and Power Distribution Systems.

7.6.1 Phase “A” Conceptual Design Submission

The intent of the Phase “A” Submission is to create a set of documents that indicates the Engineer’s Design Approach. Review of these documents by the Authority’s Engineering Department will verify that the Engineer is proceeding with design in a manner that is consistent with other Authority projects, and shall be completed prior to the advancement of the final design and plan preparation.

The Phase “A” conceptual lighting submission shall contain the following:

1. Conceptual Illumination Design Plans (in 1" = 30' scale) shall be included to review the Engineer's intent for system design. The following information shall be shown, where applicable:
 - a. Proposed roadway alignment, including striping, which is necessary to develop proper Design Areas
 - b. Existing and proposed load center(s)
 - c. All existing lighting equipment, properly labeled in accordance with Subsection 7.7.1.3
 - d. Jurisdictional limits of Authority maintenance, and required area of illumination (Design Areas) shown hatched or shaded
 - e. Design Areas for any additional lighting systems present in the project, especially those that may require coordination with the Authority-owned lighting system(s)
 - f. Design Criteria for each Design Area, including minimum and maximum value for Average Illuminance, maximum Uniformity ratio, and Light Loss Factor to be used in the calculations.
 - g. Right of Way boundaries
 - h. Signalized traffic intersections
 - i. Location of all proposed sign structures, and whether or not they require sign lighting
 - j. Location of all ITS and other roadway devices that require power, such as VMS signs, weather stations, etc.
 - k. Other information which the Engineer feels is relevant for a proper review of design intent
 - l. Specific locations of proposed lighting equipment shall not be shown
2. A preliminary lighting key plan, prepared on 1" = 100' maximum scale screened highway plans. The Preliminary Lighting Key Plan shall show all the same information as the Conceptual Illumination Design Plans, but at a smaller scale that allows for review of the design intent for the entire lighting system at a glance. The following additional information shall be shown.
 - a. Preliminary routing of proposed circuit runs, properly labeled in accordance with Subsection 7.7.1.3, for the entire Project
3. A Phase "A" Report including the following:
 - a. Overall relevant information to acclimate a reviewer to the project
 - b. A list of all applicable codes, regulations, and design guides
 - c. Completed Lighting Warrant Analysis, as described in Subsection 7.2.1
 - d. Discussion and selection of the type of Roadway Lighting System (Pole-Top cutoff, Conventional, Highmast, etc.) to be used for the design, including cost benefit analysis (see Subsection 7.2.4.2), and all applicable design criteria.
 - e. Discussion of the need for "Retrofit" type lighting standards, if applicable to the project

- f. Discussion of design intent for all electrical and communications systems necessary for equipment located within the project limits
 - g. Discussion of the additional lighting systems required in the Project and applicable design criteria
 - h. Results of the field-visit condition assessment of all existing equipment to remain and recommendations for replacement based on condition
 - i. Cost benefit analysis of locations of new utility services and standalone load centers
 - j. Analysis and need for temporary load centers for construction
4. All requests for modification of Design Criteria. See Subsection 7.1.3.
 5. A complete list of the relevant As-Built contracts, detailing the construction history of the existing lighting system installation.

The Phase “A” Submission shall be approved by the Authority’s Engineering Department prior to the preparation of lighting calculations or final plan documents.

7.6.2 Phase “B” Submission

The Phase “B” submission shall be presented in final plan format, and is intended to provide plans that show locations of lighting, electrical, and ITS devices only, along with the companion initial lighting calculations. **Power and communications distribution systems shall not be designed or included until lighting calculations, and locations of end devices, have been reviewed and approved.**

The Phase “B” Submission, at a minimum, must include the following:

1. A copy of all Design Criteria modifications that have been approved by the Authority’s Engineering Department.
2. Conceptual Illumination Design Plans, as described in the Phase “A” Submission Requirements, updated to address all review comments.
3. Lighting Plans, in final plan format, and Lighting Key Plan showing the following:
 - a. Proposed roadway alignment, including striping
 - b. Existing and proposed load center(s)
 - c. All existing lighting equipment, properly labeled in accordance with Subsection 7.7.1.3 as based on As-Built plans and field verification
 - d. All lighting standards, highmast or floodlighting towers properly plotted by stationing and fully identified by Authority standard symbols and callouts in accordance with Subsection 7.7
 - e. Underbridge luminaires, where required, with symbols shown in accordance with Subsection 7.7
 - f. Navigation/aviation lighting luminaires, where required

- g. All overhead sign structures, coordinated with lighting facilities, and bridge-mounted signs
 - h. Location of all ITS and other electrical devices, identified by Authority standard symbols, coordinated with lighting and structural facilities
 - i. Locations of new/modified electrical and communications services, along with connections to utilities
4. Preliminary Schedule of Light Standards
5. Electrical/Communications plans for non-lighting systems, in final plan format, showing installation of end devices only. Power circuitry and communications distribution do not need to be shown.
6. Full-size color prints in 1" = 30' scale showing "Preliminary" Lighting Calculations for all lighting systems, including underbridge, sign and tunnel lighting systems. Lighting calculations shall show alignment, striping, proposed light locations, existing light locations that will remain, calculation zones, and appropriate light value statistics. Light levels shall be legible for each point.
7. "Preliminary" Lighting Calculations – Two (2) CDs of the electronic calculation file(s), including all relevant photometric files and other supporting information, which may be read by the two most recent versions of the Windows operating system.
8. Phase "B" Report consisting of a status update and summary of major design points and a discussion of the alternatives analyzed and design chosen. Changes from the Phase "A" Submission shall be clearly indicated with engineering analysis and discussion. The report shall also discuss coordination efforts with all utility companies regarding new/modified services and location of electrical and communication facilities.
9. Any nonstandard CADD symbols to be used for the project legend, in order to allow coordination and use of the same symbol throughout projects.

7.6.3 Pre-Phase "C" Submission

The Pre-Phase "C" submission shall be submitted at least 4 weeks prior to the Phase "C" Submission deadline to allow appropriate time to review and include all necessary changes in the Phase "C" Submission.

The Pre-Phase "C" submission, as a minimum, must include the following:

1. Completed Sheet of General Notes, Legends, and Abbreviations
2. Completed Lighting Plans, in final plan format, and Completed Lighting Key Plan showing all information required for the Phase "B" submission, with the addition of the following information:

- a. Complete roadway lighting layout and circuitry
 - b. Load center(s), electric service locations, sign feeders, etc.
3. Electrical/Communications Plans showing complete installations, including all devices, equipment, and power and communications distribution systems.
 4. Temporary Lighting Plans showing lighting work required in order to maintain illumination on all active roadways throughout the duration of the project.
 5. Staging Plans that show the sequence of construction. If separate staging plans are not required, staging notes shall be included elsewhere in the Plans.
 6. Miscellaneous construction details, which are not covered by Standard Drawings. It should be noted that submission of such details at the Pre-Phase "C" stage may reduce the possibility of time-consuming corrections in the Phase C submission.
 7. A list of required Standard Drawings to be used on the project.
 8. Any reference plans to be included in the project.
 9. Final Schedule of Light Standards and all applicable Wiring Diagrams.
 10. Full-size color prints in 1" = 30' scale showing "Final" Lighting Calculations for all lighting systems, including underbridge, sign, and tunnel lighting systems. Lighting calculations shall show alignment, striping, proposed light locations, existing light locations that will remain, calculation zones, and appropriate light value statistics. Light levels shall be legible for each point.
 11. "Final" Lighting Calculations – Two (2) CDs of the electronic calculation file(s), including all relevant photometric files and other supporting information, which may be read by the two most recent versions of the Windows operating system.
 12. Load and circuitry voltage drop computations, in standard Authority format.
 13. Preliminary construction cost estimate.
 14. Pre-Phase "C" Report consisting of a summary of major design points focusing on any changes from the Phase "B" submission.

The Pre-Phase "C" Submission shall address all comments made during the review of the Phase "B" submission.

7.6.4 Phase “C” Submission

The Phase “C” submission shall be essentially complete, including all items listed above for the Pre-Phase “C” Submission in addition to the Supplemental Specifications and an Engineer’s Estimate. With this submission, all final design and quantity computations shall also be submitted. Copies of approved service requests and agreements with all utility companies shall be submitted for record purposes.

The Phase “C” Submission shall address all comments made in review of the Pre-Phase “C” Submission.

Submission of calculations shall generally not be required. However, if changes are made to the calculations submitted for the Pre-Phase “C” Submission, the Engineer shall resubmit a “record” set of calculations that matches the Phase “C” Submission.

7.6.5 Phase “D” Submission

The Phase “D” submission shall include the final Plans, Specifications and Engineer’s Estimate, all incorporated with the Phase “C” review comments.

7.7 PREPARATION OF CONTRACT DOCUMENTS

7.7.1 Plans

7.7.1.1 Required Plans

1. Plan preparation for either separate roadway lighting contracts or composite construction contracts containing roadway lighting shall conform to applicable requirements of Section 6A (Roadway Plan Preparation) of the Procedures Manual.
2. Contract plans shall generally consist of the following sheets, consecutively numbered:
 - a. Title Sheet: This sheet is required for separate roadway lighting contracts, not for composite contracts.
 - b. Legend, Notations and General Notes (may be more than one sheet): Legend and notations shall be prepared from the information provided as shown in Subsection 7.7.1.3 covering all installations under the Contract.
 - c. Table of Quantities: A separate sheet is not required for composite contracts, and this sheet may be combined in the Legend, Notations and General Notes sheet for small standalone roadway lighting contracts.

- d. Plan Reference Sheets: This sheet shall also include load center location(s) and all major structures. Plan Reference Sheets may be combined with Lighting Key Plan.
- e. Lighting Plans: Base plans shall be screened (subdued or gray) 1" = 30' scale Roadway plans (complete with bridge structures, guardrail and drainage) to serve as background for roadway lighting work. Numbering of roadway/site lighting plans shall coincide with numbering of the Roadway plans (i.e. the same areas of the project shall be shown on Roadway Lighting Plan 4 and Roadway Plan 4). Sheets with no roadway lighting work shall be included, and noted as "No Work This Sheet". In the case where there are multiple consecutive sheets with no electrical or lighting work, a note may be added to the adjacent sheets and the sheets with no work omitted. For example: "Plans 5 through 10 require no roadway lighting work and have been omitted for clarity".

To allow for distinction between geometry and proposed electrical and communications equipment, all roadway lighting plans shall show new roadway lighting installation in thick, bold line, existing roadway lighting equipment to remain or to be removed in a thin, solid line, and all roadway geometry, striping, utility, drainage, and other topographical information in screened linework. Any existing topographical information which shows the features to be removed (i.e. not included in the final configuration) shall be omitted from the plans unless specifically required for a temporary or staging plans. New, existing, and reference information shall be able to be determined at a glance using this approach.

Lighting Plans for roadway projects shall be titled "Roadway Lighting Plans," and lighting plans for other projects shall be titled "Site Lighting Plans."

All lighting facilities shall be properly plotted by stationing and fully identified by appropriate legend and notations. Luminaire station, offset, and tilt values shall be clearly noted. Notes shall be included on each sheet for cross-referencing and prescribing certain special installations, as required.

All existing facilities shall be shown on the Lighting Plans using the correct symbols (see Subsection 7.7.1.3). If required due to amount of work and for clarity of the proposed system, separate Removal Plans shall be permitted with prior approval from the Authority's Engineering Department.

- f. Lighting Key Plan(s): Plan(s) showing overall "final" view of installation, including all existing lighting connected to the final system. Plans shall be prepared to same standards as

Lighting Plans, only at larger scale (1" = 100' scale maximum). Lighting standard designations and circuit routing and designations, including all 24-hour power circuits, shall be clearly shown. Locations of all equipment, including load centers, sign structures, ITS devices, and other powered devices, shall be shown.

- g. Electrical / Communications Plans (if required): Plans shall show all required information to install all non-lighting devices in the project. Plans shall include a scaled geometry, all relevant topographical information, and shall generally be prepared in accordance with the criteria for Lighting Plans. Typical equipment which may require Electrical/Communication Plans are variable/changeable message signs, ITS devices, refer to Section 8 (ITS and Communication Systems) of this Manual for additional criteria, cameras, etc. Plans shall be required only if the areas of work are not coincident with the areas covered by the Lighting Plans.
- h. Staging Plans / Sequence of Construction (if required): These sheets shall also include the temporary lighting facilities and required revisions and/or removal of existing roadway lighting facilities. Plan preparation shall be as described for Lighting Plans, above.
- i. General Construction Details: These sheets shall include all required construction details which are not covered in the Standard Drawings. With the exception of one-line, wiring, and riser diagrams, all details shall be drawn to scale on accurate baseplans. Drawings of installations that rely on accurate dimensioning will be rejected and resubmission required if submitted in a "not-to-scale" format.
- j. Roadway Lighting Load Center(s) and Wiring Diagrams(s). These sheets shall clearly identify the associated work by others and all existing equipment and/or wiring being reused or removed in conjunction with the proposed work.
- k. Schedule of Lighting Standards and Luminaires: These sheets shall include a schedule for each circuit showing all proposed, existing and removed lighting facilities with final loads and phase balancing. The format of the Schedule shall be as shown below in Exhibit 7-26, which has been filled in for a "typical" new three-phase circuit. See the Sample Plans for more information.

Where single-phase circuits are used, the "Phase A", "Phase B" and "Phase C" columns shall be replaced with columns that read "Leg A" and "Leg B" to show proper balancing of the

circuit. The format as shown below may also be modified to accommodate special circumstances and projects, but should, at a minimum, include all of the information shown on the sample.

EXHIBIT 7 - 26
SCHEDULE OF LIGHTING STANDARDS AND LUMINAIRES
SCHEDULE OF LIGHTING STANDARDS AND LUMINAIRES

CIRCUIT No.1						
LIGHTING STANDARD OR LUMINAIRE No.	LIGHTING STANDARD TYPE	LUMINAIRE		BALLAST INPUT WATTS	BASE OR JBF TYPE	REMARKS
		TYPE	LAMP WATTS			
1-1-A	L-MG-40	P2	250	310	CBI	
2-1-B	L-MG-40	P2	250	310	CBI	
3-1-C	L-MG-40	P2	250	310	JBF1	
4-1-A	L-MG-40	P2	250	310	JBF1	
5-1-B	L-MG-40	P3	400	465	JBF1	
6-1-C	L-MG-40	P2	250	310	JBF1	
7-1-A	L-MG-40	P2	250	310	JBF1	
8-1-B	L-MG2-40	P4	400	465	JBF1	
9-1-C		P4	400	465		
UB3-1-A	---	W	150	190	---	
TOTALS			2850	3445		
SIGN LIGHTING SUMMARY						
STRUCTURE	QUANTITY OF LUMINAIRES	LOAD (kW)				
		øA	øB	øC	TOTAL	
STR. 091.36A	5	0.580	0.290	0.580	1.450	
STR. 091.38	2	-	0.290	0.290	0.580	
TOTAL		0.580	0.580	0.870	2.030	
CONNECTED LOAD (KW)						
-		øA	øB	øC	TOTAL	
ROADWAY LIGHTING		0.930	1.240	1.085	3.255	
UNDERBRIDGE LIGHTING		0.190	-	-	0.190	
SIGN LIGHTING		0.580	0.580	0.870	2.030	
OTHER		-	-	-	-	
TOTALS		1.700	1.820	1.955	5.475	
						LOAD (kW)
TOTAL EXISTING LOAD						0
TOTAL CHANGE IN LOAD						+ 5.475
TOTAL FINAL LOAD						5.475

- I. Standard Drawings: All required electrical and associated standard drawings.
- m. Reference Drawings: As-Built drawings related to existing roadway lighting and associated facilities. Each Reference Drawing must be referred to by specific note in the construction plans.

7.7.1.2 Additional Plan Requirements

1. Manufacturer model numbers, where included in the Plans, shall be included only once to prevent errors and inconsistencies.
2. All luminaire tilt and orientation angles other than zero (0) degrees shall be clearly shown on the Lighting Plans and Details.
3. Luminaires shall be numbered such that each circuit starts at luminaire number 1. Continuous numbering for each load center and interchange shall not be utilized.
4. Existing Authority-owned equipment (lights, conduits, wires, etc.) shall be shown on all plans using proper symbols and callouts for all areas where a Contractor could disturb as a result of construction activities, or where the Contractor is required to maintain the facilities for the duration of the Contract. It shall not be sufficient to include only notes where a Contractor is required to maintain existing facilities that are not clearly indicated on the Plans.

7.7.1.3 Standard Legends and Symbols

The Engineer shall develop a contract-specific legend for use on each project by selecting standard Authority symbols from the Standard Electrical Legends available on the Authority's website.

Any additional symbolism and/or notations required for special cases shall be reviewed by the Authority's Engineering Department before being included by the Engineer to ensure consistency between the various construction contracts.

Topographical mapping typically is created using a single symbol for all lighting poles. The Engineer shall field-verify all installations and modify the lighting and electrical symbols shown for all Plans (including those of other design disciplines and all topographical files) using the Authority's standard symbols for existing electrical and lighting equipment. This process shall both reduce confusion during construction, and shall serve to ensure that all existing lighting systems are shown correctly on the Plans.

7.7.2 Specifications

Construction of roadway lighting systems and associated electrical facilities shall conform to the following:

1. Standard Specifications.
 - a. Section 601 - Common Provisions
 - b. Section 602 - Roadway Lighting
 - c. Section 603 - Sign Lighting
 - d. Section 604 - Toll Plaza Canopy
2. Supplementary Specifications.

Specifications for additional items which are not covered in the Standard Specifications to be prepared by the Engineer shall be as follows:

 - a. Specifications shall follow the format set forth in the Standard Specifications, and shall be brief and precise.
 - b. Equipment and materials shall be specified to conform to Federal Specifications, ASTM, NEMA, ANSI, ICEA, etc., or to be equal to a particular brand product.
 - c. When brand names are used, a brief description of the equipment or material, including type, model, catalog number, etc. shall be specified. For major items, more than one brand name should be specified as acceptable, unless otherwise directed by the Authority.
 - d. Lump sum items shall be kept to a minimum in order to facilitate a more accurate estimate of cost, and to more easily negotiate field changes.